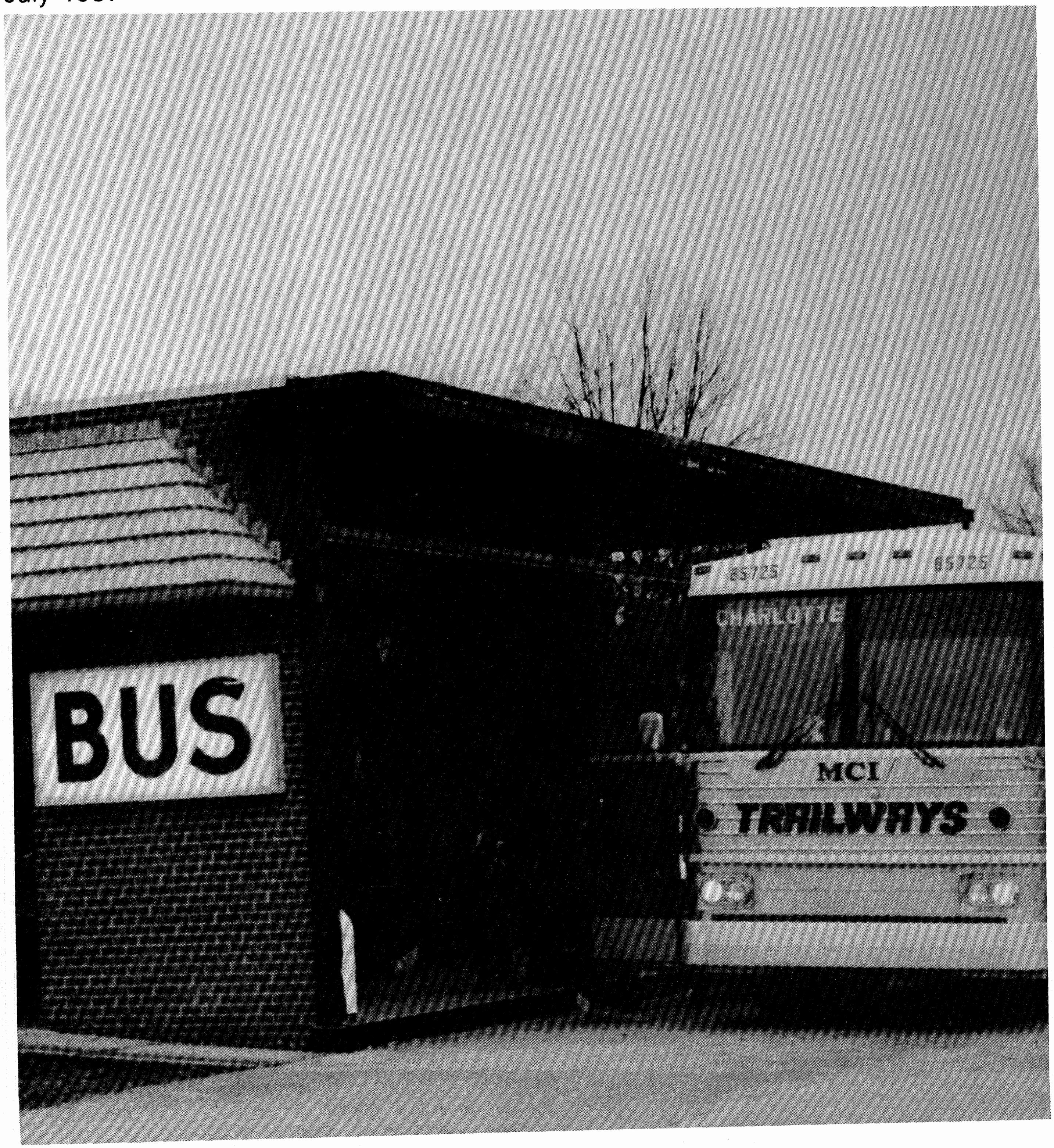
U.S. Department of Transportation
Office of the Secretary of Transportation

Planning Techniques for Intercity Transportation Services

July 1987



Planning Techniques for Intercity Transportation Services

Final Report
July 1987

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Prepared for
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DOT-I-87-22

TABLE OF CONTENTS

1

NEW APPROACHES TO PLANNING INTERCITY TRANSPORTATION SERVICES

THE CHALLENGE TO ELECTED OFFICIALS AND PLANNERS

State and local officials in rural areas and small cities across the country -- including both high-growth areas and low-growth areas -- are facing new and increasing concerns about the freight and passenger transportation services that have long connected such areas with major urban areas. Some communities are facing major changes in the price, availability, or quality of intercity transportation services which are often seen as essential to the social and economic fabric of these communities. Radical changes to these transportation services may even have important effects on the continued viability of many rural areas and small cities.

In the past, private companies provided intercity bus, rail passenger, rail freight, and air service to rural areas and between cities with minimum public involvement in the provision of service. However, those firms were regulated at the Federal, state, and sometimes local levels with regard to entry and exit from routes or services, the fares or rates they were allowed to charge, and, from time to time, safety issues. These regulations were intended to create widely available transportation services through cross-subsidies from profitable routes to support otherwise unprofitable services, such as those found in some rural areas.

Recent changes in the economics of transportation plus management decisions made possible by Federal and state regulatory reforms have combined to eliminate many of these cross-subsidies, which has led private carriers to reduce or even completely discontinue service on those routes where costs exceed revenues. Such routes are often those serving rural areas and small cities. Furthermore, Federal assistance programs that recently provided some financial assistance are scheduled to expire or cannot accommodate additional demands. Therefore, state and local officials have increasingly turned to innovative funding techniques, such as those discussed in the report entitled Innovative Funding for Intercity Modes: A Casebook of State, Local and Private Approaches,[1] in order to maintain essential intercity services. To identify which of those intercity services facing abandonment or significant price and quality changes should be considered most essential, planners and local officials need to employ the kinds of cost analyses, demand analyses, and cost-benefit analyses described in this report.

Regulatory Reform

Regulatory reform by the Federal government affected all the intercity modes serving rural and small-town America. In 1977 the Airline Deregulation Act deregulated the airlines, setting in motion a number of changes in the amount, quality, and price of air service. A series of legislative acts during the 1970's dealt with the rail industry, beginning with the creation of Amtrak in 1971 to handle a vastly reduced level of intercity passenger service, the creation of Conrail in 1976 to consolidate freight service in the Northeast, and culminating in the Staggers Act of 1980, among other regulatory reforms, which provided increased ratemaking and contracting flexibility to the freight railroads. Interstate trucking was partially deregulated by the Motor Carrier Act of 1980. In 1982, the Bus Regulatory Reform Act was signed into law, providing bus companies with greatly increased flexibility to drop or add service, as well as change rates.

[1]Frederic D. Fravel, et al. Innovative Funding for Intercity Modes: A Casebook of State, Local and Private Approaches. Prepared by Ecosometrics, Incorporated for the Office of the Secretary, U.S. Department of Transportation, May 29, 1987.

A number of states also deregulated intrastate services for some or all modes in line with the Federal actions. In some cases, the Federal statutes included pre-emption of state regulation of intrastate service under particular circumstances, such as bus service abandonments or intrastate rate cases. For other modes, state regulation has historically been minimal, as in the case of air service.

Economic Changes and the Declining Demand for Intercity Modes

Changes in rural economic activities and development patterns, coupled with the changing regulatory environment, have contributed to shifts in rural transportation requirements. Economic decline and technological change in basic industries, including coal, steel, and agriculture, has reduced rail freight demand in many areas. Completion of the interstate highway system has lowered the costs of transportation by auto, bus, and truck, often resulting in growth for many small towns in the outlying areas of major metropolitan areas. Declining fuel costs have benefited all modes with regard to the cost of operation, particularly those that are more fuel intensive. Air travel has particularly benefited from reduced energy costs. Demand for common carrier modes has declined relative to the auto, primarily due to high labor costs; new non-union carriers have developed in response to this problem.

Public officials now have to consider a variety of trends which influence the services needed for continued social and economic well-being of rural areas. These trends include:

- the decrease in the rail share of freight transportation, and the increased role of trucking to carry even bulk commodities,
- the decline of rail passenger service, with only the core Amtrak system remaining,
- the decline in demand for regular-route intercity bus service,
- the growth of air travel, including the development of commuter and regional carriers serving small cities on hub-and-spoke route systems, and
- the development of local rural and small community transportation systems to serve the mobility needs of those unable to use the private auto.

For rural areas, the results of these changes have been mixed. Auto availability has increased mobility for many, and commuter airline services have increased the frequency of service to many small cities. Trucking service continues to be provided, sometimes at lower rates than before deregulation. However, many places lost rail freight and passenger services as the rail network operated by the major carriers serving the United States shrank from 211,459 miles in 1955 to 145,764 miles in 1985. Intercity bus service was discontinued at almost 4,000 points out of the 15,000 served prior to the regulatory reform era, and service frequency has been reduced on much of the remaining network.

PUBLIC-PRIVATE PARTNERSHIPS FOR RURAL INTERCITY TRANSPORTATION

The question for state and local policy-makers is how to ensure the continued provision of service that meets mobility needs at prices that permit those in need of transportation to actually use the service. Increasingly, officials in urban areas are turning to partnership activities with the private sector as a means of reducing costs and increasing effectiveness. While rural areas receive substantial Federal funds for highway and bridge construction, the Federal programs assisting public transportation services are limited, and in many cases are being phased out as the transition period from the era of regulation is ending.[1] Solutions in rural areas and small communities will increasingly have to come from creative and cooperative efforts by the private-sector carriers and state and local officials. Many states have succeeded in recent years in pursuing public/private partnerships as a means of preserving essential services (for example, rail freight service on light density lines).

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[1]The Administration has annually recommended reduced or discontinued funding for rural transportation programs, along with other reductions in transportation spending, to help reduce the national deficit. Congress has continued to authorize transportation funds for the rural area and small communities. DOT funding for FY87 was nearly $7 billion for roads and bridges, essential air service guarantees, airport improvements, local rail assistance, public transportation, technical assistance and highway safety programs. About $6 billion of the total funding was for highways and bridges. The transportation funding levels in FY88 are about the same, with increased funding for rural technical assistance programs.

Possible Sources of Initiatives for Action

The initiative for these partnerships may originate in the public sector, the private sector, or both. On the public side, state or local governments represent the most likely source of concern for maintaining or improving services, though other governmental bodies such as regional councils, transportation districts, port authorities, and economic development groups may also take the initiative.

Private sector actors may include the intercity carriers themselves, shipper groups or associations, or other business groups. Shipper groups, which stand to gain much from continued service, can be the most critical component for insuring the success of new or replacement services, as they control, to a large extent, the demand for service. Often the initial action in the development of joint efforts is taken by the private carrier, when they seek to discontinue or change services or to increase rates in response to changed economic and regulatory conditions.

Occasionally the initiative comes from citizen groups, such as shippers affected by a change in services, business development groups, commuter groups or Chambers of Commerce. Even if these groups may not instigate actions that lead to transportation improvements, they can often be quite helpful in the development and promotion of workable options, and should be included in the processes that are used to develop and implement solutions.

Benefits of Partnerships

The benefits of private-public partnerships to maintain or improve intercity services can be many. The private carriers who have been providing transportation often have considerable expertise in the effective operation of the service. The efficiency and productivity typical of private sector transportation operations can be brought into partnership with the public goals of maintaining services. Enhanced competition resulting from deregulation may be brought to bear on behalf of the public by competitive bidding.

The public sector brings a number of beneficial roles to a joint transportation effort. It must identify the actual needs that should be met if the public interest is to be served. The public sector can provide technical assistance to carriers to identify markets and develop feasible transportation solutions. Finally, the most important role of the public sector may be in providing appropriate assistance to the private provider to enable public needs to be met in the most efficient way.

Public officials must be aware of the problems facing the private carriers in the new economic environment of regulatory reform. They must work with and encourage private carriers to provide the needed passenger and freight services where they are likely to be profitable. In cases where not all the costs of services will be met by the revenues but services are needed, officials may need to provide incentives or assistance. These will not necessarily always be financial. In some cases, state and local officials will have to encourage local acceptance of unavoidable changes, rather than attempting to provide services that are not viable in their own right or justifiable in terms of the benefits received for the costs of subsidy.

The role of the state is particularly crucial to the intercity transportation modes, a fact that has long been recognized by the Federal-state partnership in the highway program. Most intercity services, of whatever mode, cross several county and city boundaries, creating the need to develop coordinated strategies at a higher level than the strictly local arena. The transportation modes discussed here have been regulated at the state and Federal levels, with local involvement affecting terminals, local routes, and speed restrictions.

KEY POINTS ABOUT PLANNING FOR PRIVATE INTERCITY MODES

Planning for intercity modes with regard to the services they provide to rural areas and small cities differs somewhat from planning undertaken in a completely public sector area. One major difference is that the planner's area of concern is usually focused on the marginal pieces of a larger network whose economic viability depends on market forces. While it is very important for the planner and other officials to understand the workings of the market and the industry, the focus of possible actions is rarely the entire network, as it might be for an urban transit system. For this reason, system modelling efforts may not be as useful in this context, because the Federal, state and local governments have little or no control over much of the intercity transportation system, as they once did under a tighter regulatory regime.

Identifying an "essential" or "official" state network of bus, rail or air services that should be provided may be seen as analagous to planning a state highway system, and may also be a useful policy-making tool. However, if the state or local government does not have either the regulatory tools to require private carriers to provide service on that network, or the funding programs to pay for maintenance or operation on the unprofitable portions of the network, such an exercise may be of limited value.

In the past, Federal and state regulators had the intention of using entry, exit, and rate-making controls to generate cross-subsidies from profitable to unprofitable routes. Even then, route or network level analysis was rarely performed except for major rate cases or abandonment petitions. Rates were generally adjusted system-wide, so that an adequate rate of return was provided for the firm as a whole. Losses on an individual route or service did not matter as long as the firm had adequate profits. Under the current regulatory environment, profits are no longer guaranteed, making unprofitable routes now significant to private firms. While services may be abandoned on many routes where revenues are not great enough to generate profits, state and local planners may consider some of these unprofitable routes to be essential and therefore will provide planning efforts to maintain the services.

Regulatory procedures remain in place for some modes, and for some kinds of actions by the firm. These can be at the state and Federal levels, and are primarily restricted to truck, bus and rail actions. Examples include state requirements for filing intercity bus rate changes or route changes and ICC procedures for rail rates and abandoning lines. To the planner, such procedures can provide:

- a means of problem identification,
- a means of collecting data on the particular problem at hand,
- a schedule -- often very tight -- within which analyses must be made and plans developed to the point of implementation, and
- a set of procedures that will affect the eventual outcome, based on their usage by the carrier, the regulatory body, and other public officials.

An ideal scenario is one in which the planner is able to utilize regulatory proceedings to identify the problem, gather data on costs and demand, provide public involvement, and allow time to resolve funding issues. Unfortunately, the regulatory process and the planning activities are often unable to function together in this way. Regulatory agencies (particularly those staffs charged with defending the public interest) often try to maintain services through adversary actions. Planners, in the meantime, may be seeking carrier cooperation -- to provide data, submit bids, and maintain service while funding is sought. Skillfully coordinated, these roles can be complementary, but the planner must be aware of possible pitfalls resulting when the two public roles contradict one another.

Another concern that must be borne in mind by public officials dealing with rural intercity service provided by private carriers is that some traditional planning approaches may result in effects that are the opposite of that which is intended -- causing service withdrawal or reduction instead of maintaining or improving it. For example, a study which reveals in a very public way that large portions of a rail or bus network are inherently unprofitable may have the effect of forcing carrier management to take actions to discontinue service, or of deterring investors who may have been planning to provide needed capital.

Similarly, designating routes or services as worthy of subsidy, or as subsidy candidates, in advance of carriers declaring the need for assistance, may result in needless subsidy payments. Once a firm is aware that the state or local government is willing to subsidize a particular route or service, it may well decide that it would do better to ask for the subsidies (by threatening abandonment). One strategy that can be used to counter this tendency is to require that any such routes or services subsidized by the public be put out to competitive bid, thus ensuring that the current operator face the risk that another carrier would get the subsidy. Availability of capital subsidies can also distort a firm's investment decisions, leading to deferred maintenance or use of older equipment in order to qualify for the public capital funding.

In order to avoid service disruptions, a fine balance must be struck between the premature offer of assistance and the tardy response, which comes after a carrier has been forced to discontinue service (or go out of business). Once stopped, services may be extremely difficult to restart, as users lose faith in the reliability of service and begin to make alternative arrangements for transportation (or even relocate). Commitments to alternatives then prevent users from returning to the bus, rail or air service originally used, if and when services are restarted.

As a result, it may be appropriate for the public official or planner to understand the general nature of the problems facing the industry, develop procedures to analyze and deal with individual situations in a timely manner, and then be able to respond quickly when a carrier indicates that it is no longer able to provide services without assistance of some sort.

A Model Planning Process for Rural Intercity Modes

Bearing in mind the issues described above, a good example of a planning process for rural intercity modes is that originally developed for railroad branch line analysis by the Federal Railroad Administration (FRA). It involves an on-going process to:

- inventory services and conditions in the industry serving the state,
- identify potential problem areas,
- collect data on the costs of needed capital investment or operating assistance,
- examine current revenues, demand, and potential revenues, and
- provide a formal methodology to evaluate the costs and benefits of potential public projects, in order to use scarce public resources for the most worthwhile projects.

While this planning process is used as a basis for the development of an overall planning process (see Chapter 2), many of the detailed methods used in the process developed by FRA and the states for rail planning cannot be directly implemented for the other modes. Abandonment of rail branchlines involves a prescribed schedule of regulatory steps, some of which are designed to produce disclosure of the data that would be needed for project analysis. Other modes, with little remaining Federal regulation, or pre-emption of state regulation, require different techniques to produce the needed data.

The methods of accomplishing many of the steps in the overall process vary considerably with the mode being analyzed, the remaining regulatory and reporting framework, and the availability of data. The remainder of this guidebook presents some procedures from the literature that can be used to address the analysis of service costs, estimate potential demand, and examine costs and benefits of intercity service projects in rural and small urban areas. Where available, the outcomes of their use are also noted. In every case, the users of these techniques should be aware that they are part of a larger process that requires considerable additional information and judgement to provide a complete context within which to interpret the results of applying these techniques.

USING THIS MANUAL FOR PLANNING INTERCITY SERVICES

The existence of highly structured Federal assistance programs to build highways or urban public transportation systems has provided both defined planning processes and techniques that can be applied to answer the critical questions posed by transportation needs for these modes. Intercity services in rural areas are seldom planned in such a prescribed way.

The intercity services of concern in this manual have historically been provided by private carriers and regulated at the Federal, state or local levels. The public involvement in the past has been almost completely regulatory in nature. Public planning, in the sense that it has been used in planning highways, the airway system, or urban public transit services, has not been applied. Nevertheless, the possibility of public activities in cooperation with the private sector requires the ability to know when such assistance is required, and whether the public benefits require something other than completely market-based solutions.

This handbook is intended to introduce a process for public sector planning of these private intercity modes in rural areas. It also presents several methodologies that can be applied to provide some partial answers to basic questions regarding the cost and demand for services, and whether or not the potential public costs will return enough benefits to make the project worthwhile.

This chapter has presented a number of the considerations which must be borne in mind when planning for private-sector involvement in rural intercity transportation. The second chapter presents an overview of the planning process. Chapter 3 discusses the estimation of costs for intercity services. The fourth chapter presents methods of estimating demand. Chapter 5 is a presentation of cost-benefit techniques applied to intercity services in rural areas, and the final chapter discusses ways in which modal alternatives can be evaluated.

2

A PLANNING PROCESS FOR RURAL INTERCITY MODES

This chapter presents a process that state or local planners and other officials can use when dealing with rural intercity services, and provides a framework for utilizing the techniques presented in the following chapters. Together, the process and the techniques are intended to aid in the analysis and evaluation of intercity bus, rail freight, regional air, and rail passenger services.

An overall framework, or planning process, is important because it may aid in the identification of potential service problems or opportunities before a crisis occurs, giving planners and elected officials time to gather the needed data, to evaluate what the public interest in particular services might be, and to decide on the appropriate actions. Because these modes are in the private sector and are essentially unsubsidized, decisions by the operators are based on market factors and may occur quickly, leaving little time for public response. A planning process can at least ensure that planners and other officials are aware of the issues affecting the industry, the services provided, their importance, and potential alternative responses.

The process can be thought of as discrete stages of information gathering, analysis, and decision-making, each with a number of different techniques used to accomplish the task. Differences in the regulatory controls, reporting, and funding possibilities for each mode in each locale require the use of different methods within each of the stages, though in general the process will follow many of the same steps regardless of mode. Ideally, the process should begin before a crisis such as an abandonment filing or request for public support for a new service creates pressures for immediate decisions. Early detection of potential problems in the provision of desirable services may even aid in permitting coordinated efforts among users, public bodies, and the carrier to avert a crisis later on.

Figure 2-1 presents a basic description of the steps in a generalized planning process for the intercity modes. It consists of nine steps occurring in four stages, which are

- identification of problems and opportunities,
- assessing the public interest,
- project analysis, and
- analysis of costs and benefits.

IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

In this stage, the planners or other officials examine the role of the intercity transportation services in their areas of jurisdiction to gain an understanding of the public interest in them, and to become aware of possible future opportunities or problem areas. The first step is an inventory of the industry providing the service, including its organization, services, plans, and current issues.

Industry Analysis

Planners and other state or local officials should first inventory the services provided in their jurisdiction by the modes under review, including the routes, schedules, terminals, characteristics of the vehicles (age, size or capacity), fares or rates, and organization of the industry.

Much of this data was formerly available through reports filed with regulatory agencies at the state and Federal level. Service characteristics are generally available from service guides, or from the carriers. Information about the firms may be available from regulatory reports or the firms themselves. In general, this stage of the process should involve contacts with firm's management, perhaps as part of the data collection process, or as members of an advisory committee to the program or study team engaged in the process.

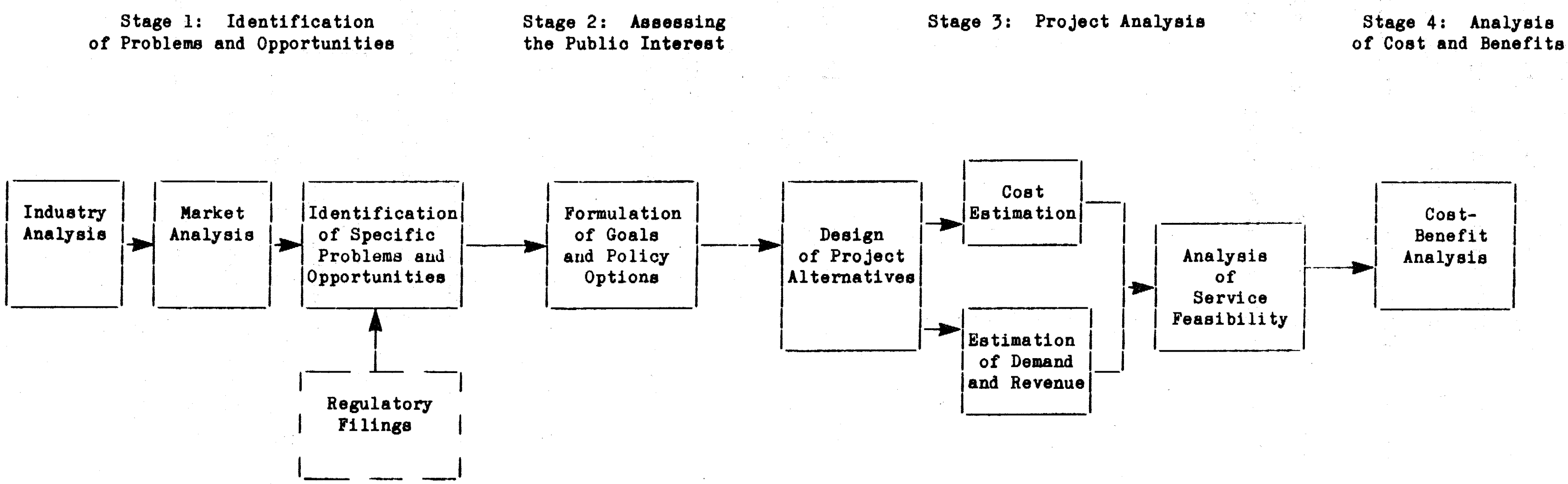

Figure 2-1: AN OVERALL PLANNING PROCESS FOR INTERCITY TRANSPORTATION MODES

An important part of the inventory process is the identification of issues affecting the industry which could affect the future availability of service, such as declining usage (perhaps in particular areas, or among particular groups), cost increases, regulatory difficulties, competitive pressures, or combinations of these factors. Carrier plans for future growth, new services, or possible changes in product mix (such as a shift from regular-route to airport bus service) should also be identified. This context within which the transportation industry operates is important, as factors affecting the industry generally may be translated into specific problems at the local level.

Market Analysis

This step in the problem identification stage is directed at the users of the transportation services and at those who are indirectly affected by possible service changes. In this case, the process would be directed at determining who the customers are now, what are their characteristics, what changes would they like, and what are their alternatives.

Depending on the mode, the time available, and the issues, this step could involve surveys of intercity bus, regional air, intercity rail, or ferry passengers. It could also involve surveys of shippers using rail freight service, or even potential shippers located along rail routes. In some places, market research techniques have been used to contact non-users and ask why the service does not meet their needs.

This step can be limited to examining the size and characteristics of the aggregate market and looking at recent trends, or it can go as far as using demand models to predict the aggregate demand in the future under different scenarios of fuel prices, economic activity, and other influences. The main purpose is to understand the need and demand for the transportation services in a general sense.

Identification of Specific Problems and Opportunities

Combining the results of the first two steps should provide an indication of specific problem areas or places in which coordinated action could result in additional or improved services. Ideally, this is the point at which early warning signs become apparent, such as reductions in usage to levels that are not economically viable to the carrier, or declining service quality.

For each mode the early warning signs may be different, and the measures of problems are therefore unique to each. For branchlines it may be a decline in the number of carloads per track-mile or unavailability of cars (as described in the example below). For intercity buses, it may be reductions in frequency to once a day, or on demand only. For regional air service, it may be frequent turnover in carriers serving a particular airport or a decline in enplanements. Often the carriers, if invited to participate in the process, can be quite helpful in identifying the problems.

AN EXAMPLE OF EARLY WARNING SIGNALS CONCERNING POTENTIAL PROBLEMS WITH INTERCITY TRANSPORTATION SERVICES: RAIL FREIGHT SERVICES

One procedure for determining whether or not a rail branch line is being operated profitably is to take the annual number of carloads of traffic which originate or terminate on a given branch line (or a terminal segment of a branch line) and divide this number by the length of the line in miles. If the result is substantially above 70 carloads annually per mile, the line is probably profitable. If the result is substantially below 70 carloads annually per mile, the operation of the line by a major railroad is likely to be unprofitable (though operation by a smaller "short-line" railroad may be profitable).

It should be noted that this "70-carloads annually per mile" rule is only a rough indicator of profitability. Other factors affecting profitability are: the type of service required on the line (it is less costly to pick up 25 cars once from a grain elevator than to pick up or deliver the same number of cars, two or three at a time, several times a week); the profitability of the traffic generated by the line; and the degree to which service to the line can be meshed with other rail operations. Furthermore, the 70-carload rule applies only to major railroads. It has been suggested that short-line railroads have a good chance of succeeding if their lines generate at least 40-carloads annually per mile and they can hold down costs, and they have a very good chance of succeeding if their lines generate at least 60 carloads annually per mile; below the 40 carloads per mile level, the chances of success for a short-line railroad become more tenuous, and below 20 these chances are probably nil.

Other early warning signs of note include track deterioration, poor service, or failure to supply shippers with an adequate number of cars.[1]

[1]For further details see two publications of the North Carolina Department of Transportation's Transportation Planning Division: <u>How To Deal With Railroad Abandonment</u>, second edition, 1983, and <u>Preserving Local Rail Service</u>, 1985.

An alternative means of identifying problems is to rely on the regulatory process. Carriers may file to discontinue service, change frequencies, raise rates, or offer new services. Because of the history of regulatory control, in many places such filings remain the initial means of defining problems, or of public awareness of changes in an industry. Railroads and intercity bus lines continue to have to file many such changes, first with state agencies and then with the ICC. Air service, seldom regulated at the state level, is now subject to few Federal regulations, so the carriers themselves are the best sources of information.

A major problem with relying on the regulatory process as the only means of problem identification is that this strategy does not begin to operate until a problem has become a crisis, and then many of the actors are already operating in adversarial roles, often under tight deadlines. Also, if there are actions that states or local areas could be performing to support or attract new services, such opportunities are unlikely to be identified in regulatory filings. It does, however, provide a major means of data collection.

ASSESSING THE PUBLIC INTEREST: FORMULATION OF GOALS AND POLICY OPTIONS

The second stage is really the determination of the possible policy options available and the goals that each is intended to support. Unlike a classical planning process that begins with goal formulation, we have included such activities after information is available on the industry, its role, the usage of the services, and the problems or opportunities it presents. Goal formulation should precede the development of programs for funding or supporting services, in order that scarce resources not be wasted on projects not in the overall public interest.

PROJECT ANALYSIS

Once problems and opportunities have been identified, and the public goals and objectives for rural intercity service determined on a general level, the process turns to the analysis of the specific project. The first step in this stage includes the determination of the nature of the needed assistance. It is possible that awareness of a potential problem can lead directly to actions by users and others to prevent a later crisis, such as increasing usage of the service, increasing public awareness, or providing public terminal facilities. This may avert the need for further analysis or the development of projects.

However, if such actions do not appear to be sufficient, at this point the steps include design of project alternatives, developing cost estimates, estimating usage and revenues, and then determining whether additional funding would be required for the services.

Design of Alternatives

Planners may have already determined from the problem analysis what some of the likely alternatives may be. They can range from marketing and technical assistance, to limited assistance in funding particular capital inputs (such as low-cost bus loans, rehabilitating terminals, etc.), to capital investments in facilities. Operating assistance can include limited types such as provision of help on insurance costs or driver layover facilities, relief from taxes or user fees, or purchase of service under contracts.

Cost Estimation

Cost estimation depends on the alternatives selected. If the alternatives are restricted to capital projects, engineering cost estimates of the required actions should be obtained, either from the carrier or from independent sources. For operating projects, actual operating costs should be obtained for the most recent operator. These should be compared to estimated costs using industry unit costs as a means of evaluating whether or not the problem is carrier efficiency. In many transportation industries, new carriers with lower operating costs are able to operate marginal services successfully and, if possible, low-cost operator unit costs should also be applied. Operating costs should also be evaluated for capital projects, as capital investment may change the operating costs (indeed, this could be a major benefit of such investments). Chapter 3 of this report presents three methods for estimating the operating costs for rail branch line service, intercity bus service, and regional airline service.

Estimation of Demand and Revenues

The feasibility of the service depends on the relationship between revenues and demand. Demand is the actual usage of the service, given its fares or rates and its operating characteristics. In general, decision-makers should use actual usage data as the beginning of the analysis, comparing usage to estimated demand based on the behavior of users of similar services elsewhere. This can be done by using simple models calibrated on other services to predict demand and comparing the predictions to the actual figures. Simple demand estimation techniques for intercity bus and regional airline service are presented in Chapter 4 of this report. For rail branch line service, the number of potential users is generally very small, and they should be contacted directly. Revenues can be estimated by taking the demand estimates and multiplying them by average fares or, if average trip lengths are known, the rate per passenger-mile or per ton-mile can be used to compute revenue.

Analysis of Service Feasibility

In this step, the costs of alternatives are compared to the expected revenues to determine the feasibility of the service. It may well be that improved carrier operating efficiencies (perhaps from a new, lower-cost carrier) can lower costs sufficiently so that the service is feasible without further assistance. However, if it appears that public assistance for operating costs or for capital investments is required, the benefits to the public from this expenditure must be compared to the costs, and a determination made as to whether or not public support is justified.

ANALYSIS OF COSTS AND BENEFITS

At this stage, the costs and benefits of alternative levels of public involvement in the project or service are compared. In the basic methodological sense, a calculation of the costs and benefits is made, based on the data developed in the earlier steps of the process. Chapter 5 of this report presents an overview of cost-benefit analysis methods, as well as examples of public assistance applied to capital investments and to operating assistance for rail branch line improvements and rural intercity bus services.

The process of determining costs and benefits can include many more factors. Policies on regional equity, redistribution, and assisting special need groups can and should also be included in this process.

Public resources are generally scarce, but are even more scarce for assisting rural intercity modes. Care must be taken that public resources invested in projects or programs (if any) be likely to return the maximum amount of public good, and this stage in the process is intended to provide planners and public officials with an understanding of the tools required to perform this task.

SUMMARY

The process presented here is very general. Transportation planners will need to do additional work to fill in the specific steps for any mode or any particular situation. This handbook is intended to provide a beginning, and to present several specific techniques for accomplishing steps in the process. The remainder of the volume is dedicated to the specific methods mentioned above.

3

ESTIMATING COSTS OF INTERCITY SERVICES

This chapter presents techniques for estimating costs as part of the planning process for intercity modes in rural areas. The tools presented are straightforward, basic formulas for estimating the operating costs of intercity bus service, branchline rail freight service, and short-haul airline service. The presentations here are brief but they include the essentials along with examples from actual situations. The techniques rely on data from published sources describing existing routes or services for each of the modes. In each case, those persons analyzing costs for a particular service should make every effort to find out the costs incurred by the current or most recent operator. Such information can then be updated or adjusted to reflect cost increases or changes in the planned operation.

INTERCITY BUS COST ESTIMATION PROCEDURES[1]

This technique provides the user with a procedure for estimating the cost of operating a new intercity bus route or revising service on an existing route.

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[1]This cost estimation procedure was originally prepared by Ecosometrics, Incorporated under subcontract to Peat, Marwick, Mitchell & Co. for inclusion in Intercity Bus Service Planning -- Final Report, prepared for the National Cooperative Highway Research Program, National Research Council, March 1983.

The technique relies on unit cost data from existing routes, special surveys from published references to similar systems. Data generated by special efforts are usually most accurate but most expensive, if such data are not available, or if time or money are constraints, unit cost estimates should be substituted where appropriate. Unit costs will vary by class of carrier and must be periodically updated for inflation using appropriate factors for each cost category.

The procedure for estimating costs of a specific intercity bus route consists of four steps which are shown on the worksheet in Table 3-1. The four steps are to estimate service characteristics, to estimate operating costs, to estimate approximate capital costs, and to estimate total annual costs. Information identifying the corridor, service option, region, and type of carrier should be recorded on the top of each worksheet. Each step can be completed using the guidelines described in the following paragraphs.

Step 1: Estimate Service Characteristics

Three service characteristics are required in this costing procedures: annual bus miles, annual paid driver hours, and number of buses required for the route.

Annual Bus Miles

Annual bus miles is estimated in Step 1.A of Table 3-1. It consists of the sum of annual operating miles and annual deadhead miles. Annual operating bus miles can be estimated by multiplying the one-way mileage times the weekly one-way frequency. An estimate of weekly deadhead mileage for a route also should be estimated and entered in the appropriate box of Step 1.A.

Annual Paid Driver Hours

The total number of paid driver hours is calculated in Step 1.B. Annual driver hours include:

- Revenue driver hours (i.e., hours driving a bus in scheduled service)
- Layover hours between scheduled runs (including "clerical" hours each day to stage buses, complete paperwork, etc.)
- Deadhead hours involved in driving a bus empty to a starting point or terminal

Table 3-1: COST ANALYSIS WORK SHEET -- INTERCITY BUS SERVICE

Corridor: ____________________ Service Option: ____________________
Region: ____________________ Carrier Class: ____________________

STEP 1: ESTIMATE SERVICE CHARACTERISTICS

A. Annual Bus Miles (BMT)

Operating Miles
One-Way Mileage x ________
Weekly One Way Frequency ________
= ________

Deadhead Miles
Weekly Deadhead Mileage ________

Total Annual Miles (BMT) = (Operating Miles + Deadhead Miles) x 52
= (____________ + ____________) x 52 = ________

B. Annual Paid Driver Hours (ADH)

Revenue Hours
Weekly Revenue Driver Hrs ________

Non-Revenue Hours
Weekly Layover Hours + ________
Weekly Deadhead Hours + ________
Weekly "Dead" Hours + ________
Weekly Other Hours + ________
= ________

Total Annual Paid Driver Hours (ADH) = (Revenue + Non-Revenue) x 52
= (______ + __________) x 52 = ________

STEP 2: ESTIMATE OPERATING COSTS

Cost Element	Unit Cost (from Table 3-2 or 3-3) (A)	x	Inflation Index (From Table 3-4) (B)	x	Annual BMT (From Step 1.A) (C)	=	Annual Cost
Maintenance	/BMT		(Maintenance Index)				
Fuel	/BMT		(Fuel Index)				
Driver	/BMT		(Drivers Index)				

Total Operating Costs = (Maintenance + Fuel + Driver) x (Overhead Rate)
= (__________ + ____ + _____) x (   ) = $ __________

STEP 3: ESTIMATE "FIRST CUT" ANNUAL CAPITAL COSTS

A. Number of Buses ________ (N)
B. Capital Cost per Bus $ ________ (C)
C. Length of Lease (Years) ______ (L)
D. Prevailing Interest Rate ______ (S)

Determine Approximate Annual Lease Cost = ________________
(From Table 3-5)

STEP 4: ESTIMATE TOTAL ANNUAL COSTS

Total Costs = Operating Costs (______) + Capital Costs (_______) = $ _______
(From Step 2) (From Step 3)

Source: Peat, Marwick, Mitchell & Co., Intercity Bus Service Planning - Final Report. Prepared for the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, March, 1983.

- If full-time drivers are to be employed, "dead" hours are those for which no service is performed but for which drivers are paid to guarantee 40 hours weekly wages. Following Bureau of Motor Carrier Safety (BMCS) regulations, it should be assumed that each driver is not employed more than 60 hours per week or more than six consecutive days at a time. If the schedule for the particular service requires a driver for fewer than 40 hours a week (say 35 hours), then the extra hours (and resulting wages) should be added to the cost of the route. However, if part-time drivers are used, it is not necessary to include the cost of these "dead" driver hours.

The sum of the five time components (revenue, layover, deadhead, "dead", and other hours) equals the total paid driver hours.

Number of Buses Required

The number of buses needed for a specific route over a 24-hour period is determined by analyzing the actual or assumed schedules. This information is needed to estimate the capital cost of a route as well as to estimate annual paid driver hours.

Any significant deadheading from (or to) the garage to (or from) the first departure point should be included in this determination. The analyst should ascertain whether back-up vehicles for the proposed route would already be available in a potential operator's existing fleet. If not, the cost of the necessary back-up vehicles should be included as capital expense for the proposed route or improvement.

Step 2: Estimating Operating Costs

Operating costs for either an existing or proposed service are estimated in Step 2. These costs vary directly with bus activity, and include driver wages, fuel and oil expenses, and garage, equipment, and maintenance expenses.

Unit costs for a particular carrier can be calculated based on that carrier's submissions to regulatory bodies. However, in cases where carriers do not operate on designated routes, or where "order of magnitude" cost estimates are desired and need to be calculated quickly, a set of cost estimates can be useful which reflect average or typical values applicable to a relatively broad range of situations. Such default estimates for operating costs for

Class I carriers[1] for 1979 are presented in Table 3-2. Unit operating cost measures for Class II and some smaller Class I operators are presented in Table 3-3.

Driver Labor Costs

The labor cost for drivers is estimated by taking the number of paid driver hours required for the proposed service from Step 1.A and multiplying that number of hours by the estimated driver hourly rate. (This rate is the paid rate only, not including fringe benefits. Fringe benefits on all personnel are included in the overhead rate.) Carrier-specific hourly rates should be used in this calculation, if available.

Garage, Maintenance and Fuel Expenses

Garage, maintenance and equipment expense per bus mile (GME) and fuel and oil expense per bus mile (FBM) values may come either from estimates of such values (Tables 3-2 and 3-3) or from actual carrier costs. These costs are calculated in Step 2. These unit costs should be increased from 1979 values to current year estimates with the use of the appropriate inflation factors (i.e., motor vehicle and parts products price index for GME and refined petroleum products estimated for FMB). Inflation factors for fuel and maintenance (respectively) to adjust costs from 1979 to current levels are described below. Bus miles travelled (BMT) is estimated in Step 1.

Updating Operating Unit Cost Estimates for Inflation

Unit operating costs are presented for either 1979 (fuel expenses per bus mile, garage maintenance expense per bus mile) or for 1980 (driver labor rates per hour). It is important that these unit costs be estimated in current year prices. Inflation factors for a specific year can be developed for each of the three categories of unit costs by dividing the particular price index for that year by the price index for the base year. Table 3-4 presents the factors to inflate costs to particular levels; for prices more current than those shown, the reader should contact the U.S. Bureau of Labor Statistics.

[1]For accounting purposes, carriers are classified by the ICC according to the revenues they generate. Class I carriers have an average gross operating revenue in excess of $3 million. Carriers generating revenue of $3 million or less are classified as non-Class I carriers.

Table 3-2

1979 CLASS I UNIT COSTS

	Equipment and Garage Expenses per Bus Mile	Fuel and Oil Per Bus Mile	Drivers' Wages Per Bus Mile
National Average[a]	$0.20	$0.12	$0.33
Range	0.13 - 0.29	0.10 - 0.12	0.26 - 0.40
Northeast Average[a]	$0.25	$0.12	$0.36
Range	0.19 - 0.32	0.11 - 0.13	0.32 - 0.40
Central Average[a]	$0.18	$0.12	$0.32
Range	0.16 - 0.20	0.10 - 0.13	0.28 - 0.36
Southeast Average[a]	$0.17	$0.11	$0.30
Range	0.11 - 0.25	0.10 - 0.13	0.24 - 0.34
West Average[a]	$0.17	$0.12	$0.32
Range	0.16 - 0.19	0.10 - 0.13	0.27 - 0.36

[a]These values were calculated by rejecting the highest and lowest values in each category and calculating the average remaining unit values.

Note: There is a wide range in the unit costs for Class 1 carriers. Consequently, comparisons of average unit costs among Class 1 carriers and with non-Class 1 carriers should be carefully made.

Source: Peat, Marwick, Mitchell & Co., Intercity Bus Service Planning - Final Report. Prepared for the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, March, 1983.

Table 3-3

1979 BUS COST MEASURES
FOR NON-CLASS I AND SMALL CLASS I OPERATIONS

	Equipment and Garage Expenses per Bus Mile	Fuel and Oil Per Bus Mile	Drivers' Wages Per Bus Mile
National Average[a]	$0.18	$0.13	$0.27
Range	0.06 - 0.38	0.08 - 0.25	0.14 - 0.44
Northeast Average[a]	$0.24	$0.16	$0.34
Range	0.12 - 0.75	0.09 - 0.31	0.23 - 0.73
Central Average[a]	$0.15	$0.12	$0.22
Range	0.06 - 0.29	0.08 - 0.15	0.09 - 0.30
West Average[a]	$0.20	$0.14	$0.26
Range	0.06 - 0.38	0.06 - 0.21	0.14 - 0.44

[a]These values were calculated by rejecting the highest and lowest values in each category and calculating the average remaining unit values.

Note: There is a wide range in the unit costs for non-Class 1 and small Class I carriers. Consequently, comparisons of a verage unit costs among such carriers and with large Class 1 carriers should be carefully made.

Source: Peat, Marwick, Mitchell & Co., Intercity Bus Service Planning - Final Report. Prepared for the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, March, 1983.

Table 3-4: PRICE INDICES FOR INFLATION ADJUSTMENTS (1967 = 100)

Price Index	1979	1980	1981	1982	1983	1984	1985	1986	Operating Cost Factor for
Refined Petroleum Products Producer Price Index	444.8	674.7	827.7	761.2	684.3	665.1	633.1[1]	405.3	Fuel
Motor Vehicles and Equipment Producer Price Index	190.5	208.8	237.5	251.3	256.8	261.5	267.3	274.4	Maintenance
Urban Consumer Price Index	217.7	247.0	272.3	289.1	298.4	311.1	322.2	328.4	Drivers
Public Transportation Price Index	200.3	251.6	312.0	346.0	362.6	385.2	402.8	426.4	

Source U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Indexes and Monthly Labor Review.

Procedures for Estimating Overhead Costs

The overhead ratio is the ratio of total operating costs to the sum of drivers' wages, equipment, maintenance, and garage expense, and fuel and oil expense. A "first cut" overhead ratio of 1.9 is suggested for Class I carriers. However, this value appears to be too high for Class II carriers, who may incur proportionately less station, advertising, and administrative expenses than larger carriers. A value centering around 1.6 is suggested for Class II carriers.

To calculate total operating costs in Step 2, the three operating expenses (fuel, maintenance, and driver wages) should be summed and multiplied by the appropriate overhead ratio to estimate total annual operating cost.

Step 3: Estimate Capital Costs and Depreciation

In this step, the estimation of capital costs focuses on costs of vehicles (buses and vans). It should be noted that fixed facilities (depots, garages, etc.) can also involve capital expenditures, but are not considered here due to the highly variable nature of such costs.

The capital cost of each bus as calculated in Step 3 assumes that intercity buses are leased by operators under a "closed end" lease. That is, the market value of the bus at the end of the lease is agreed upon at the beginning of the lease, so that the lessee (operator) need not compensate the lessor for any additional decline in the bus market value at the end of the lease. Lease costs, as computed here, are based on the depreciation of vehicles. If arrangements other than closed-end leasing are to be used, the capital expenses for those arrangements should be entered here instead.

Annual lease costs to an operator of an $180,000 bus are presented in Table 3-5, assuming that the lease covers annual depreciation plus interest. As is evident in the Table, as the length of the lease (and thus amount of depreciation) increases, and as the interest rate increases, annual costs also increase. The lease costs assume that the lessee will pay for the maintenance and garaging of the bus. The lessor is not assumed to pass through to the lessee any investment tax or business energy tax credit savings.

Step 4: Estimate Total Annual Costs

The total annual cost of the proposed service is the sum of the total annual operating cost from Step 2 and the annual capital cost from Step 3. The values obtained in Table 3-1 in Steps 2 and 3 should be added and then recorded in Step 4 in the table.

Table 3-5

APPROXIMATE ANNUAL LEASE COSTS OF A FULL-SIZE INTERCITY COACH BUS[1]

Length of Lease (years)	Annual Lease Cost as a Function of Various Interest Rates			
	9%	12%	15%	18%
3	$23,703	$24,981	$26,279	$27,595
4	21,609	23,046	24,519	26,023
5	20,567	22,193	23,865	25,582
6	20,063	21,890	23,871	25,732

[1]Assumes a full-sized 46-passenger intercity coach with restroom, total 1987 cost = $180,000.

Source: Calculations by Ecosometrics, Incorporated.

Example of Intercity Bus Cost Estimation

Table 3-6 presents an example of a calculation of route level costs for 1986 operating cost data from a Class I intercity bus carrier operating in the Southeast. The carrier is a regional carrier providing some regular-route service, but mainly charter and tour operations. The firm is unionized. The service characteristics concern a rural route, with a route length of 103 miles, and one trip per day each way. It is fairly typical of services that could possibly require assistance. One bus is required to operate the service, though it would appear that the service could be operated by using a single bus

Table 3-6: COST ANALYSIS WORK SHEET -- EXAMPLE

Corridor: Sample — Service Option: Daily, 1 Trip Each Way
Region: Southeast — Carrier Class: I, Unionized

STEP 1: ESTIMATE SERVICE CHARACTERISTICS

A. Annual Bus Miles (BMT)

Operating Miles
- One-Way Mileage x 103
- Weekly One Way Frequency 14
- = 1,442

Deadhead Miles
- Weekly Deadhead Mileage 28

Total Annual Miles (BMT) = (Operating Miles + Deadhead Miles) x 52
(1,442 + 28) x 52 = 76,440

B. Annual Paid Driver Hours (ADH)

Revenue Hours
- Weekly Revenue Driver Hrs 42

Non-Revenue Hours
- Weekly Layover Hours + 10.5
- Weekly Deadhead Hours + 1
- Weekly "Dead" Hours + 2.5
- Weekly Other Hours + --
- = 14

Total Annual Paid Driver Hours (ADH) = (Revenue + Non-Revenue) x 52
= (42 + 14) x 52 = 2,912

STEP 2: ESTIMATE OPERATING COSTS

Cost Element	Unit Cost (from Table 3-2 or 3-3) (A)	Inflation Index (From Table 3-4) (B)	Annual BMT (From Step 1.A) (C)	Annual Cost
Maintenance	.25/BMT	274.4/190.5 = 1.44	76,440	$27,526
Fuel	.13/BMT	405.3/444.8 = .91	76,440	9,050
Driver	.34/BMT	328.4/217.7 = 1.51	76,440	39,244

Total Operating Costs = (Maintenance + Fuel + Driver) x (Overhead Rate)
= ($27,526 + 9,050 + 39,244) x (1.9) = $ $144,059

STEP 3: ESTIMATE "FIRST CUT" ANNUAL CAPITAL COSTS

A. Number of Buses 1 (N)
B. Capital Cost per Bus $ 180,000 (C)
C. Length of Lease (Years) 6 (L)
D. Prevailing Interest Rate 9% (S)

Determine Approximate Annual Lease Cost = $20,063
(From Table 3-5)

STEP 4: ESTIMATE TOTAL ANNUAL COSTS

Total Costs = Operating Costs ($144,059) + Capital Cost ($20,063) = $164,122
(From Step 2) (From Step 3) = $2.15/Bus Mile

Source: Example prepared by Ecosometrics, Incorporated for Peat, Marwick, Mitchell & Co., Intercity Bus Service Planning - Final Report. Prepared for the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, March, 1983.

for only about eight hours per day. However, because the route is operated during the day, it is not possible to count on having alternative uses for the bus during the evening and night, and the entire cost of one bus must be attributed to the route. As can be seen on the example worksheet, the estimated cost per bus mile for this route is $2.15. For a 47-seat intercity bus, this works out to $0.046 per available seat-mile (ASM).

REGIONAL AIRLINE COST ESTIMATION TECHNIQUES

A cost estimating model for regional airline services has been developed by Clint Oster and Andrew McKey[1]. Primarily developed as a tool for economic analysis, it could also be used for planning purposes if actual cost information is not available, or is suspect for some reason. In structure it is similar to the bus cost model, but includes many more cost components. In part this is because of the great variety of stage lengths, aircraft size and crew composition, service levels, and overhead costs among short-haul airlines.

Oster and McKey divide the costs of providing air service into three categories: 1) capacity costs, 2) traffic-related costs, and 3) overhead costs. Capacity costs are those related to ownership of the aircraft, flying, and maintenance. Major categories include the labor costs of the flight crew, fuel, maintenance, oil, landing fees, and equipment costs. The latter category includes depreciation or rental and leasing fees, and insurance on the plane.

In this analysis, representative short-haul aircraft types were used, and operating cost data for those planes taken from the FAA approved manufacturer's manuals. These included the block fuel and time costs for markets of 50, 100, 150, 225, 300, and 500 miles. Labor cost inputs assumed in the development of the model used entry level wages, varying by aircraft type, with pilot salaries ranging from $15 per hour for the Piper Chieftain to $40 per hour for jets. Fuel costs of $1.08 per gallon were used. Block hour salaries of first officers varied from $10 to $20, and all flight attendants were paid $6 per hour.

Using both block fuel and time to assign the correct values to each category, the formula for calculating the costs for a given aircraft on a particular segment can be stated as follows:

$$\text{TOTSC} = \text{FUEL} + \text{CREW} + \text{MO} + \text{MAINT} + \text{EQUIP} + \text{LANDF},$$

---

[1]Clinton V. Oster, Jr., and Andrew McKey, "The Cost Structure of Short-Haul Air Service", Chapter 4 in John R. Meyer and Clinton V. Oster, Jr. Deregulation and the New Airline Entrepreneurs, Cambridge: The MIT Press, 1984 pp. 52-86.

where:

TOTSC = total segment costs,

FUEL = fuel costs,

CREW = flight crew costs,

MO = miscellaneous flying expense and oil costs,

MAINT = maintenance cost,

EQUIP = cost of owning and insuring aircraft,

LANDF = landing fee,

Total costs for a given market (TOTMC) are the product of the frequency of flights and the cost per segment:

$$TOTMC = FREQ \times TOTSC.$$

Frequency is a function of policy (in the case of Essential Air Service cities), demand, load factor, and seating capacity of the plane.

Each of the components listed in the above formula is in turn calculated from other factors. The formulas for each of these components are presented below:

$$FUEL = FUEL_p \times FUEL_b,$$

where:

$FUEL_p$ = price of fuel per pound, and

$FUEL_b$ = block fuel consumption (pounds).

$$CREW = T_b \times (1 + EBR) \times [PILOT_w + COPILOT_w + (FA_n \times FA_w)],$$

where:

T_b = block time,

EBR = employee benefits and payroll taxes = 0.3

$PILOT_w$ = pilot salary per hour (range from \$15 to \$40 per hour),

$COPILOT_w$ = copilot salary per hour (range from \$10 to \$20 per hour),

FA_n = number of flight attendants,

FA_w = flight attendant wage per hour (\$6.00 per hour).

$$MAINT = CYCLE + (T_b - T_g) \times FLTHR$$

where:

CYCLE = maintenance cost per cycle,

FLTHR = maintenance cost per flight hour,

$(T_b - T_g)$ = flight time

T_g = taxi or ground time.

$EQUIP = (T_b + T_t) \times [(AO + HI)/PH]$ $AO = PRICE \times [(1\text{-}RV) \times CRF)]$,

$HI = (RATE \times PRICE)$,

where:

T_b = block time

T_t = turnaround time = 15 minutes

AO = annual aircraft ownership cost

HI = annual hull insurance cost

PH = annual peak hours = 2,080

PRICE = aircraft purchase price

RV = residual value = 0.15(PRICE)

CRF = capital recovery factor = 0.05 (constant)

RATE = annual hull insurance rate.

$$MO = T_b \times MOEXP$$

where:

MOEXP = combined miscellaneous and oil expense per block hour.

$$LANDF = FEE \times LANDWT$$

where:

FEE = landing fee per 1,000 pounds landing weight = 0.30(constant)

LANDWT = aircraft landing weight.

Where possible, values have been provided for many of the factors included in the formulas. Other sources, in addition to the carriers that are likely to be providing the services in question, include commuter airline journals, such as Business and Commercial Aviation, which provides an annual aircraft performance chart in its April issue. This guide to currently available aircraft includes calculation of fuel consumption, speed (time), trips possible, seat-miles per hour and per pound of fuel for three different stage length missions (75, 150, and 275 miles). It is reprinted in the Annual Report of the Regional Airline Association. However, it does not provide cost values for crew wages, the price of fuel, etc., which must be supplied by the analyst.

Using the values for 1982 cost inputs developed by Oster and McKey, Figure 3-1 presents a graph which could be used to approximate the cost of operating a given aircraft type over a particular stage/route length. Table 3-7 provides some information on several typical aircraft used for short-haul air service. As an example, for the same route length and frequency used in the intercity bus cost example, the annual operating cost of a 50-seat DeHavilland Dash 7 (compared to a 47-seat bus) over a 100 mile trip 14 times per week would be about $400,000 per year, as compared to $164,000 for the bus. Such a comparison is not very realistic, however, as the higher speeds of the aircraft would permit it to make many more trips in a day. Thus a smaller plane could be used to provide higher frequencies which may result in increased demand. Figure 3-2 presents the cost per available seat-mile (ASM) for a number of common short-haul aircraft types. As indicated, these dollar values are based on 1982 costs, and any use of these graphs to estimate costs should make adjustments to account for inflation since that time.

ESTIMATING COSTS OF RAILROAD BRANCHLINE OPERATIONS

Like short-haul airlines and intercity bus services, methods have been devised to enable planners to estimate the cost of rail operations on short-lines. The state of Wisconsin, in its 1983 update of the state rail plan[1] has

[1]The Wisconsin State Rail Plan. Submitted to the Federal Road Administration, U.S. Department of Transportation. Wisconsin Department of Transportation, 1983 Update.

Table 3-7

TYPICAL SHORT-HAUL AIRCRAFT CHARACTERISTICS

Aircraft	Type	Seating Capacity
DC-9-80 (MD-80)	Low-Wing, 2-Engine Turbojet	155
DC-9-30	Low-Wing, 2-Engine Turbojet	115
DeHavilland Dash 7	High-Wing, 4 Turboprop Engines	50
Shorts 330-200	High-Wing, 2 Turboprop Engines	30
Fairchild Metro IIA	Low-Wing, 2 Turboprop Engines	19
Piper Chieftain	Low-Wing, 2 Piston Engines	8 or 9

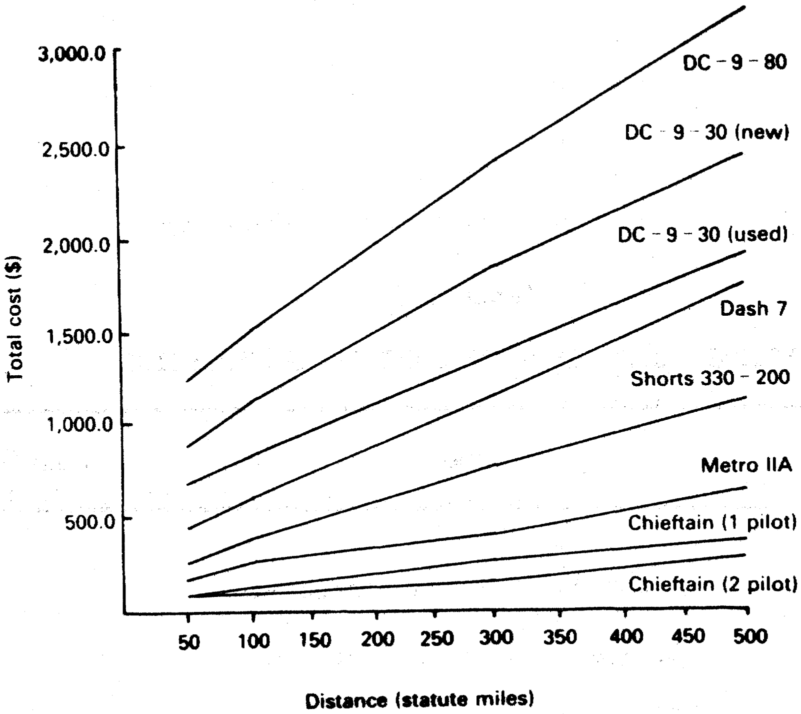

Figure 3-1: OPERATING COST VS. DISTANCE (1982)

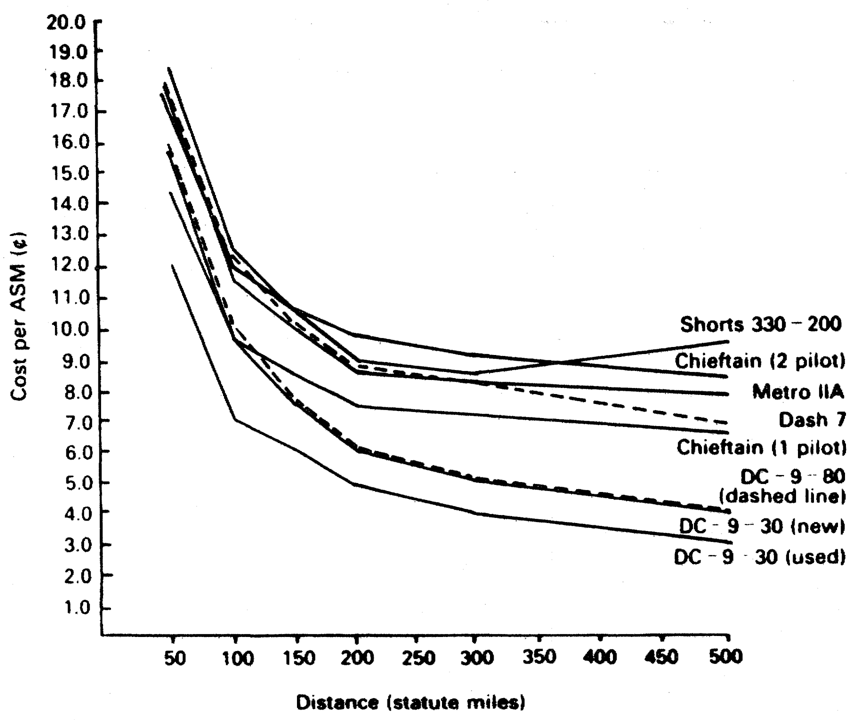

Figure 3-2: SHORT-HAUL AIRCRAFT OPERATING COST PER ASM VS. DISTANCE (1982)

included a usable methodology, based on United States Railroad Association (USRA) methods,[1] which forms the basis of the section included here.

As in the case of the other modes, the planner is advised to obtain unit cost data for the particular service or operator under study, if at all possible. Industry unit costs can be used if there is no current service, or if no data is available. However, the continuing role of the ICC in railroad regulation provides a data source for carrier unit costs, which can be derived from the R-1 Rail Carrier Annual Report to the ICC. This report is the annual report of financial and operating statistics that each rail carrier is required to submit to the ICC. The ICC can supply paper or microfiche copies of these reports. State regulatory agencies may also require carriers to file the R-1, or state reports. In addition, regulatory abandonment proceedings can also require a carrier to disclose fairly specific data regarding the costs of operating a particular line.

The Wisconsin/USRA methodology divides costs into three categories. One is on-branch costs -- those incurred in operating rail freight service on the particular branch line. The second major grouping is off-branch costs, which are the costs of hauling the freight on other lines, off the branch. The third category is the return on investment. A summary of these cost formulas is presented in Table 3-8. Each of these cost categories will be discussed in turn.

On-Branch Costs

On-branch costs are divided into seven categories that are conceptually similar to those in the intercity bus and short-haul airline models. The first cost category is that of crew costs.

Basically, crew costs are a function of the total number of hours in service on the line, the number of persons in the crew, their base and overtime pay rates, constructive allowance, and fringes such as health and welfare benefits and payroll related taxes. A crew cost per hour can be constructed for each railroad company by using crew costs reported in the R-1 carrier annual report to the ICC, dividing total crew costs for a particular type of employee by the total hours of service to give an average cost per hour. The costs

[1] United States Railway Association. Viability of Light-Density Rail Lines -- The United States Railway Association's Analytic Policies and Procedures, Washington, March, 1976.

Table 3-8

SUMMARY OF COST FORMULAS

1.	On-branch costs		
	a. crew costs	=	number of hours on-branch per trip x number of trips per year x average per-hour crew cost
	b. locomotive cost	=	number of hours on-branch per trip x number of trips per year x locomotive cost per hour x number of locomotives
	c. car-day cost	=	number of carloads x average days on line per car x cost per car-day
	d. car-mile cost	=	number of carloads per year x cost per car-mile x average on-branch haul (mile) x 2 (round trip)
	e. caboose-day cost	=	number of round trips per year x number of hours per trip ÷ 8 hours per caboose-day x cost per caboose-day
	f. caboose-mile cost	=	number of round trips per year x length of line (mile) x cost per caboose-mile
	g. maintenance cost	=	length of line (mile) x average yearly maintenance cost per mile
2.	Return on Investment		
	return on net salvage value	=	(land value + value of ties + value of reusable rail + value of scrap iron - cost of recovery) x rate of return
3.	Off-branch costs		
	a. line haul cost	=	[number of carloads x (average length of off-branch haul x unit car-mile cost + number of tons x average length of off-branch haul) x unit ton-mile cost]
	b. terminal cost	=	[(number of carloads x unit carload cost) + (number of tons x unit ton cost)] x .19
	c. on-system off-branch costs	=	(line haul cost + terminal cost) x $\frac{\text{on system revenue}}{\text{total haul revenue}}$
	Net contribution = net profit (deficit) of operations	=	(revenue) - [(on-branch cost) + (return on investment) + (off-branch cost)]

Source: The Wisconsin State Rail Plan. Submitted to the Federal Railroad Administration, U.S. Department of Transportation, 1983 Update.

for each employee-type needed for a crew are then aggregated to give the cost per hour for two, three, four and five-person crews, for each railroad. Table 3-9 presents some crew costs per hour for different size crews in Wisconsin, as computed by the State Department of Transportation in 1981. Obviously, these figures would have to be revised to account for inflation since that time. A source of current information on labor costs is the "Index of Charge-Out Prices and Wage Rates" published annually by the Association of American Railroads in Washington, D.C.

The second major cost category is locomotive costs, which include total costs for repair, depreciation, rent, fuel, indirect maintenance and labor costs and a return on investment figure. Wisconsin used 7.2 percent for that figure. The other costs were also obtained from the R-1 reports of the relevant carriers, and the system cost of these locomotive related costs was then divided by locomotive hours to produce a cost per locomotive hour. Table 3-10 presents some 1981 locomotive costs for particular railroads in Wisconsin.

The third cost category of the on-branch cost group is related to the cost of cars used on the branch line. Car costs are broken into those related to the number of days a car is used on the line, and those that are a function of the number of miles that the car is operated. They are both calculated by using a unit cost per car-day and per car-mile, times the number of hours and miles that cars are used on the branch. Wisconsin calculated per mile and per day costs by commodity to 1981 cost levels, as presented in Table 3-11. These cost factors are then applied to estimate on-branch car-miles and car-days. On branch car-miles are estimated by taking the average round-trip distance on the line, while car-days are a function of switching, loading, and waiting times, along with frequency of service. Table 3-12 presents factors for calculating car-days, based on frequency of service.

A similar method is used to develop the costs of using cabooses on the branchline, if they are required by state law or union agreements. The number of caboose-days is multiplied by a unit cost of $15.57 per day, then adjusted for inflation since 1981. Caboose-mile costs were calculated by Wisconsin to be $0.081 per mile in 1981. It should be noted that increasingly railroads are doing away with the use of cabooses, and these costs should not be automatically included in a cost estimation.

Table 3-9

1981 CREW COSTS FOR SELECTED WISCONSIN RAILROADS

	Crew Costs per Hour			
	C&NW	MILW	SOO	ICG
Two Man Crew	44.35	44.16	44.02	44.62
Three Man Crew	62.81	62.55	62.34	63.20
Four Man Crew	81.27	80.94	80.67	81.78
Five Man Crew	101.04	100.63	100.30	101.68

Source: Computed by WisDOT from 1978 annual reports of the carriers (R-1's) and factored by 1.450 to represent 1981.

Table 3-10

1981 LOCOMOTIVE COSTS FOR SELECTED WISCONSIN RAILROADS

	Locomotive Unit Costs Per Hour
C&NW	39.85
MILW	56.07
SOO	35.36
ICG	39.78

Source: Computed by WisDOT from 1978 annual reports of the carriers (R-1's) and factored by 1.450 to represent 1981.

Table 3-11: ON-BRANCH UNIT COST FACTORS FOR SELECTED WISCONSIN RAILROADS

		CNW		MILW RD		SOO		ICG	
Code	STCC Name	Cost/ Car-Day	Cost/ Car-Mile	Cost/ Car-Day	Cost/ Car-Mile	Cost/ Car-Day	Cost/ Car-Mile	Cost/ Car-Day	Cost/ Car-Mile
01	Farm Prod.	4.8321	1.741	6.9505	.0786	4.6032	.0656	4.4099	.0519
08	Forest Prod.	2.9020	.0873	5.0181	.1057	3.3235	.0938	3,1838	.0811
09	Fresh Fish	3.6500	.0673	6.3115	.0855	4.1798	.0802	4.0044	.0598
10	Metallic Ores	4.5061	.0551	7.7921	.0749	5.1605	.0589	4.9437	.0459
11	Coal	4.5061	.0551	7.7921	.0749	5.1605	.0589	4.9437	.0459
13	Crude Petroleum	0.0449	.1455	0.0779	.1617	.0515	.1552	0.0494	.1440
14	Nonmetallic Ores	4.4430	.0564	7.6829	.0760	5.0882	.0604	4,8746	.0474
19	Ordinance	4.3304	.0578	7.4882	.0770	4.9591	.0635	4.7510	.0489
20	Food or Kindred	3.4067	.0722	5,8908	.0887	3,9013	.0805	3.7381	.0638
21	Tobacco	4.3216	.0579	7.4726	.0771	4.9490	.0636	4.7410	.0490
22	Textile Mill Prod.	4.2808	.0583	7.4024	.0777	4.9024	.0649	4.6967	.0498
23	Apparel	3.2067	.0740	5.5479	.0917	3.6745	.0928	3.5199	.0676
24	Lumber	4.4972	.0563	7.7765	.0749	5.1500	.0590	4.9339	.0462
25	Furniture	4.3440	.0574	7.5117	.0769	4.9747	.0633	6.3752	.0485
26	Pulp-Paper Prod.	4.3890	.0569	7.5895	.0765	5.0262	.0619	4.8153	.0480
27	Printed Matter	3.5689	.0686	6.1714	.0869	4.0870	.0831	3.9154	.0616
28	Chemicals	2.6317	.0920	4.5506	.1099	3.0139	.0998	2.8871	.0861
29	Petroleum Prod.	1.0680	.1245	1.8466	.1414	1.2231	.1331	1.1717	.1213
30	Rubber & Plastics	4.2763	.0583	7.3946	.0777	4.8972	.0649	4.6917	.0498
31	Leather	3.5327	.0690	6.1089	.0873	4.0458	.0845	3.8758	.0623
32	Stone, Clay, Conc.	4.4251	.0564	7.6518	.0757	5.0676	.0604	4.8549	.0474
33	Primary Metal	4.4027	.0565	7.6129	.0760	5.0418	.0616	4.8302	.0479
34	Fab. Metal Prod.	4.1591	.0602	7.1921	.0794	4.7632	.0677	4.5630	.0517
35	Machinery	4.1817	.0598	7.2312	.0789	4.7890	.0673	4.5877	.0513
36	Electric Machinery	4.1232	.0606	7.1296	.0797	4.7219	.0689	4.5236	.0525
37	Trans. Equip.	4.3530	.0573	7.5271	.0769	4.9850	.0628	4.7757	.0484
38	Instruments	3.6637	.0679	6.3350	.0866	4.1956	.0804	4.0191	.0608
39	Mis. Prod. of Manu.	3.8663	.0643	6.6855	.0830	4.4275	.0750	4.2416	.0564
40	Waste & Scrap	4.3710	.0579	7.5583	.0774	5.0056	.0619	4.7954	.0489
41	Misc. Freight Ship.	3.6093	.0679	6.2414	.0865	4.1337	.0822	3.9600	.0609
42	Empty Containers	3.2083	.0736	5.5479	.0910	3.6745	.0906	3.5199	.0670
44	Freight Forwarded	2.8390	.0792	4.9091	.0963	3,2511	.1024	3.1146	.0739
45	Shipper Assoc.	2.6901	.0812	4.6518	.0983	3.0808	.1063	2.9515	.0762
46	Misc. Mixed Ship.	1.6267	.0967	2.8129	.1123	1.8627	.1343	1.7846	.0941

Source: 1975 Rail Form A computations by RSPO factored by 1.714 to represent 1981 costs.

Table 3-12

AVERAGE CAR-DAYS ON A BRANCH LINE

Frequency of (Trips per Week)	Local Traffic	Intrasystem Traffic	Interline Traffic
1	19.00	11.00	11.00
2	15.29	8.29	8.29
3	12.05	6.38	6.38
4	11.07	5.82	5.82
5	10.43	5.63	5.63
6	9.14	4.64	4.64
7	8.00	4.00	4.00

A final, and not insignificant, on-branch cost is that of maintenance of way. Average 1981 costs per mile for maintenance, based on the amount of traffic over the line, are provided in Table 3-13. Obviously costs for such maintenance will vary considerably with the number of tunnels, bridges, etc. and, if at all possible, a specific engineering estimate of maintenance costs should be made. Specific costs can only be estimated by having experienced railroad engineers inspect the facilities and develop cost estimates of needed repairs based on the actual condition of the line.

Table 3-13

AVERAGE MAINTENANCE COSTS

Millions of Annual Gross Ton-Miles	Average Annual Maintenance Cost per Mile ($)
0.0 - 0.19	$ 6,338
0.2 - 4.99	7,503
5.0 - 9.99	8,456
10.0 - 14.99	14,704
15.0 - 19.99	18,184
20.0 - 24.99	21,699

Source: Viability of Light Density Rail Lines. USRA, March, 1976, page 99. Costs inflated to 1981 figures by WisDOT.

Off-branch costs must also be included in any cost estimation, just as off-branch revenues are included on the other side of the ledger. The components of these costs include line-haul cost and terminal costs.

Line-haul costs are calculated based on the variable unit costs per car-mile and ton-mile, along with the average length of haul. The average length of haul is based on the commodity type, and the territory of the origin-destination, less the average length of haul for a branch line. Statistics on the length of haul by commodity type are available from the AAR Carload-Waybill Statistics. Some 1981 line-haul costs by car type are presented in Table 3-14. These would need to be updated to current values.

Terminal cost reflects the cost of switching movements. Unit costs of such terminal movements are based on variable car-mile and tonnage related costs. Table 3-13 also presents terminal costs per car-mile and ton, for particular car types.

A final, and most significant cost, is the return on investment in the branch. It is the opportunity cost to the carrier of remaining in operation. In this technique, it is developed by applying a desired rate of return to the salvage value of the branchline, including the land, rail, and ties. Wisconsin applied figures of $82 per ton for scrap steel, $5.00 per usable tie, $160-270 per ton for reusable relay #1 rail, and $140-$230 per ton for relay #2 rail. These figures could be adjusted by checking with salvage operators and railroad suppliers. Railroad land value is usually hard to estimate, because the alternative uses for a right-of-way may be limited or non-existent. In 1981, Wisconsin used $400 per acre for rural land, and $26,136 per acre for urban land. In order to release these assets, dismantling and removal would have to take place, estimated at $11,000 per mile in 1981. After taking the net liquidation value of the branchline, a rate of return of 16.5 percent was applied, based on ICC findings of the average cost of capital in 1981. More recent information or other capital values could be applied.

The total operating cost is the sum of these three cost components: on-branch costs, off-branch costs, and return on investment. The net profit on the branch is the amount remaining after these costs are subtracted from the revenue attributable to the branch.

Table 3-14

LINE HAUL AND TERMINAL COSTS FOR OFF-BRANCH COST CALCULATIONS

	Line Haul Costs		Terminal Cost	
	Per Car-Mile	Per Ton-Mile	Per Car-Load	Per Ton
Box - General-Unequipped	$.60919	$.006801	$227.62	$0.17566
Box - General-Equipped	.71667	.006801	227.52	0.17566
Box - Special	.88988	.006801	244.25	0.17566
Gondola - General	.76476	.006801	244.25	0.17566
Gondola - Special	.78974	.006801	244.25	0.17566
Hopper - Open-General	.75141	.006801	244.25	0.17566
Hopper - Special	.75010	.006801	244.25	0.17566
Hopper - Covered	.77742	.006801	244.25	0.17566
Stock	.76553	.006801	244.25	0.17566
Flat - General	.70488	.006801	244.25	0.17566
Refr. - Meat-Mech.	1.09274	.006801	147.73	0.17566
Refr. - O/T Meat-Mech.	.90269	.006801	147.73	0.17566
Refr. - Meat-Non Mech.	1.10140	.006801	147.73	0.17566
Refr. - O/T Meat-Non Mech.	.84501	.006801	147.73	0.17566
Tank - 10,000-18,999 Gal.	.97427	.006801	147.73	0.17566
Tank - 28,000-31,999 Gal.	1.11017	.006801	147.73	0.17566

Sources: Rail Carload Cost Scales. ICC, 1977. For Region V (average trains) for 1977 factored by 1.520 to 1981. Viability of Light Density Rail Lines. USRA, March 1977, pp. 83-85.

The Wisconsin methodology described here relies on the use of cost data from the annual report to the ICC of Class I railroad carriers.[1] In many cases the unit costs derived in this way will correctly fit the situation in which a Class I carrier wishes to abandon service on a branch. Operating costs of smaller, short-line replacement carriers will be lower, though it is likely that any project involving such a transition would involve capital costs to rehabilitate the line to a serviceable standard. Additional costs for a short-line operation include the administrative costs detailed in Table 3-15. Off-branch costs are omitted from the calculation for short-line operations, and the crew, locomotive, car-day and car-mile unit costs should be reduced to actual levels of the short-line operation. The formulas are the same as for the Class I operators. Wisconsin suggests $3,500 per mile per year as the appropriate cost of short-line maintenance of way, if actual is not available.

Capital cost estimates can be supplied by the railroad owning the line, and are often supplied as part of the case for abandonment. An alternative source of capital cost estimates is independent engineering estimates of the cost of needed renovations. In general, estimating the capital cost of the rehabilitation of a branch line should not be done using the kind of parametric cost estimating techniques used here for operating costs.

CONCLUSION

Estimating the costs of operating intercity bus, short-haul airline, and rail freight service on branch lines can be done using the methods presented in this chapter. Planners and officials seeking to use any of these methods must realize that the data sources for the unit costs will probably be somewhat different from those described here, as public reporting requirements have changed greatly in recent years. These descriptions provide a methodology that can be used, but they will undoubtedly require much local adaptation and refinement to produce reliable cost estimates.

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[1]The ICC has established three classes of rail carriers. Class I carriers have annual revenues in excess of $50 million; Class II carriers are those with annual revenues between $10 million and $50 million; and Class III have annual revenues less than $10 million. Class III also includes all switching and terminal railroads.

Table 3-15

ADMINISTRATIVE COSTS FOR A SHORT-LINE RAIL FIRM

a.	transit commission expenses	\$1,000 to \$2,000 per year
b.	legal services	\$5,000 to \$10,000 per year
c.	insurance	\$15,000 per year
d.	damage claims	\$2,000 per year
e.	finance and accounting	\$5,000 to \$17,000 per year
f.	management and supervision	\$20,000 to \$30,000 per year
g.	fringe benefits	(finance and accounting salary + management and supervision) x 25 percent
h.	taxes	assessed value x tax rate
i.	marketing and customer services	\$3,000 to \$7,000 per year
j.	office and maintenance building	\$10,000 per year
k.	radio communications equipment	\$400 per year
l.	office equipment and supplies	\$600 per year
m.	miscellaneous expenses	\$5,000 to \$10,000 per year

Source: Wisconsin Department of Transportation. State Rail Plan 1983 Update, p. B-7.

4

ESTIMATING DEMAND FOR INTERCITY SERVICES

Another important step in the planning process for rural intercity services is estimating the demand for the services. No matter how low the costs, the demand must exist for the service to be viable or to have benefits that exceed the costs. Often the actual demand for the service at current rates can be determined from data supplied by the carrier, or from other direct survey results. Such information provides at least one point on a demand curve, and can provide an indication of the potential demand that may not be currently using the service.

In this chapter an intercity bus demand estimation model is presented, and an example of its use on the same hypothetical route used in the cost chapter is included as an illustration of the technique. In addition, two regional airline demand models are also presented -- one a fairly simple equation using population and distance to the nearest hub as explanatory variables, and the other a more sophisticated simultaneous equation model. The demand models available for rail services are substantially more complex than those for other modes, and they will not be discussed here.

The planner or analyst using these models must realize the limitations inherent in their use, including their inability to deal with markets that are much different from those used to calibrate the models and the limitations on their accuracy. While the intercity bus models explain about two thirds of the variation in the demand per trips, both the simple and the more complicated versions of the airline models are only able to explain about 40 percent of the variation in enplanements among cities. For that reason, a number of other factors affecting the demand for regional airline services are also discussed. Officials should take these other factors into account, perform local surveys of key employers and travel agents, and take other steps to fully understand the local market for air travel in addition to using these models.

Demand for rail freight service is best estimated by surveying shippers on the particular routes that carriers have designated as possibly subject to abandonment. For that reason, we have not included any branchline rail freight models. Rail passenger service models have been developed in a number of different studies -- some being multimodal -- and others predicting rail demand only. Amtrak has its own proprietary demand model which it uses to check the reasonableness of state-provided demand estimates when evaluating state-funded 403(B) service. Estimating the demand for a complete 403(b) route or schedule in a manner that meets Amtrak requirements would require more space and development than can be provided in this guidebook, and so nothing has been included regarding demand estimation for intercity rail passenger service.

ESTIMATING THE RIDERSHIP ON INTERCITY BUS ROUTES

This section describes a means for estimating the ridership on intercity buses on a particular route. A simple estimating technique was developed from data for 89 routes in 17 states.[1] The number of riders on a particular route was found to depend on the frequency of service, the population served, the fare, and the route's distance. The procedures discussed are simple and inexpensive. They are also intuitively correct and reasonably accurate. They are intended for use as part of a sketch planning exercise which should be followed by more thorough analysis of the routes that appear promising. As with all estimating procedures, those described here should be used with care.

This model has been applied in studies of rural bus service in Illinois, North Carolina, and Tennesse. In Illinois, the Greyhound service between

[1]Jon E. Burkhardt and Jeffrey I. Riese. "Estimating Travel Demands for Intercity Bus Routes." Paper presented to the Transportation Research Board, January, 1982.

St. Louis and Vincennes, Indiana was analyzed.[1] The model predicted ridership greater than the actual ridership, possibly because schedule changes had made day trips to St. Louis impossible. In North Carolina, it was used to estimate bus ridership on the Outer Banks, between Elizabeth City and Manteo. Model estimates were very close to actual ridership on the service provided by Virginia Dare Transportation Co. (which received UMTA Section 18 funds).

The Data Base

Examining over 200 routes, 114 routes in 17 states for which complete data existed were selected to generate the data needed for estimating demand on a route-by-route basis. For purposes of demand estimation, routes of less than 20 miles were eliminated, leaving 89 routes to be analyzed. These 89 routes had an average ridership of almost 2,000 passengers per month, at approximately seven dollars per trip, from an average service area population of 200,000+ persons. Several routes crossed state boundaries. Other relevant statistics for the routes comprising the data base are shown in Table 4-1.[2]

The data represent the full range of routes serving rural and small urban areas. No routes serving only large urban areas were included. Bus companies with only one route were included, as were the major carriers which serve cities throughout the U. S. No formal distinction was made between express and local routes. Some of the routes had varying scheduled stops (some regular stops became flag stops on certain runs), but as long as the end points specified were served, the route was included.

Details of the Recommended Approach

Components of the Models

In general, the models are of the following format: the number of passengers on a given route is a function of the frequency of service, the population

[1]Joe Kott. "St. Louis-Vincennes: Problems and Opportunities in Preserving Bus Service to Six Illinois Counties." Illinois Commerce Commission, Springfield, Illinois, November 1984, pp. 35-37, and Appendix a, Table A.

[2]It may not be possible to use the models described here to accurately predict ridership on intercity bus services whose characteristics fall significantly outside of those shown in Table 4-1.

Table 4-1

CHARACTERISTICS OF 89 INTERCITY BUS ROUTES USED TO FORECAST PASSENGER DEMAND ON ROUTES OVER 20 MILES IN LENGTH

Variables	Mean	Standard Deviation
One-Way Passengers per Month (boarding)	1,926	3,602
One-Way Distance (miles)	95	45
One-way Fare (dollars)	$6.78	$4.24
Scheduled Run Time (minutes)	152	72
Round-Trip Frequency (per week)	15	16
Total County Population (all persons in all counties served)	568,311	547,061
Route Specific Population (all persons in cities, towns, villages, directly on route)	214,800	198,400
1979 Per Capita Income (average for the total population)	7,109	1,146
Origin City Population (persons)	106,177	141,363
Destination Population (persons)	74,280	127,764
Monthly Bus Miles (Frequency x Round Trip Distance)	11,544	11,491
Fare/Mile (cents)	6.35	1.69

Source: Data collected by Ecosometrics, Incorporated and Peat, Marwick Mitchell and Co.

served, the cost to the rider, and the distance of the trip. The variables included in the model are the most significant intuitive causes of demand, their relationships and elasticities are consistent with existing references on the demand for intercity bus travel, and the best of the models account for about two-thirds of the overall variance in demand among the routes studied.

The models that proved to be acceptable were of the following format:

$$PASS/MO = CONST \times RTFREQ^{a} \times SERVPOP^{b} \times FARE/MI^{c} \times DIST^{d}$$

where

PASS/MO = the number of one-way passengers boardings per month for the route segment specified

CONST = a constant specifically derived for this equation

RTFREQ = scheduled round trips per week on the route

SERVPOP = the population served -- defined as the sum of the populations of villages, towns, and cities directly along the route -- divided by 100

FARE/MI = fare per mile in cents, found by dividing the cost of a one-way fare between the endpoints of each route by the one-way distance between the endpoints of the route

DIST = one way distance between the endpoints on the route

a = the exponent for round trip frequency

b = the exponent for service population

c = the exponent for fare per mile

d = the exponent for one-way distance.

Specific Models for Estimating the Demand for Intercity Bus Travel

Table 4-2 shows models that provided the best explanation of the variations in patronage among the 89 routes analyzed. Separate equations are presented for routes of different distances. This stratification by distance was done because intercity trips of different length are quite different in terms of trip purpose and frequency. The only equation including distance as a significant variable is the last equation which estimates demand for the entire data base of 89 routes.

Table 4-2: REGRESSION MODELS FOR ESTIMATING TRAVEL DEMAND ON INTERCITY BUS ROUTES IN SMALL URBAN AND RURAL AREAS

GENERAL MODEL: # Passengers = $(\text{frequency})^a \times (\text{population})^b \times (\text{fare})^c \times (\text{distance})^d \times \text{constant}$

SPECIFIC MODELS:

Route Distances (miles)	Passengers Per Month	=	Round Trip Frequency	x	Population Served	x	Fare per Mile	x	Distance	x	Constant
20-60	"	=	Frequency$^{1.032}$	x	Population$^{0.376}$	x	Fare$^{-0.645}$	x	(N.A.)	x	17.989
20-120	"	=	Frequency$^{1.093}$	x	Population$^{0.409}$	x	Fare$^{-0.352}$	x	(N.A.)	x	6.871
121+	"	=	Frequency$^{0.415}$	x	Population$^{0.726}$	x	(N.A.)	x	(N.A.)	x	1.510
20+	"	=	Frequency$^{0.893}$	x	Population$^{0.484}$	x	Fare$^{-0.268}$	x	Distance$^{-2.61}$	x	17.219

where:

Passengers/Month = Number of passenger boardings on the route per month.

Round Trip Frequency = Scheduled round trips per week on the route.

Service Population = The population served, defined as the sum of the populations of villages, towns, and cities along the route, divided by 100.

Fare/Mile = Fare per mile in cents, found by dividing the cost of a one-way fare (in 1980 dollars) between the end points of each route by the one-way distance between those end points.

Distance = One-way distance between endpoints of the route.

Because of the functional form of the model being used, the regression coefficients constitute the demand elasticities of the respective variables. Seen in this light, the results of the equations are most satisfying. First, all of the signs of the coefficients are intuitively correct:

- increases in frequency of service lead to increases in ridership,
- increases in the service area population lead to increases in ridership,
- increases in fares lead to decreases in ridership, and
- increases in trip distance lead to decreases in ridership.

Second, the elasticities shown in these equations are similar to previously documented ranges. Furthermore, the fare elasticity behaves as expected with respect to distance. Third, all of the regression coefficients in the equations shown were found to be statistically significant. Therefore, the equations can be used with a relatively high degree of confidence in their accuracy.

The user of these models should select the most appropriate models according to individual circumstances. The person using any of the equations only needs information for the route or routes to be analyzed. The population, distance, fare, and frequency data can be assembled for a single route within several hours.

Step-by-Step Procedures

The procedures for applying the intercity bus demand models are relatively straightforward. Some research on the area's characteristics and several decisions regarding desirable system characteristics are necessary. Then the model can be applied.

Identify Area Characteristics

Information about two factors must first be found: the population that will be served and the distance covered by each route. The population can be determined through census or census-type materials. The total mileage of each route will have to be determined by direct measurements for each specific route.

Choose Service Characteristics

The analyst must then specify

- the average frequency of service on all routes, and
- the fares that will be charged.

It is important to remember these specifications can be changed over and over again for multiple iterations of the model, so that it is not wise to agonize for a long time over the precise numerical specification of a particular factor.

Calculating the Demand

Table 4-3 outlines step-by-step procedures for calculating demands with a calculator. In general, the procedure is to find the value for each variable times its exponent, then to multiply all the resulting values times each other.

Examples of Calculations with the Models

Consider a proposed route with the following characteristics:

- population served, expressed in hundreds: $152{,}645 \div 100 = 1526.45$
- one-way route distance: 103 miles
- round trip frequencies: 14 times per week
- one-way fare per mile: 10.18 cents per mile.

These values are then entered into the demand equation for routes from 20 to 120 miles, which is

$$\text{PASS/MO} = \text{RTFREQ}^{1.093} \times \text{SERVPOP}^{0.409} \times \text{FARE/MI}^{-0.352} \times 6.871$$

Thus,

$$\text{PASS/MO} = (14)^{1.93} \times (1526.45)^{0.409} \times (10.18)^{-0.352} \times 6.871$$

$$= 17.89 \times 20.05 \times .4418 \times 6.871$$

and, therefore,

PASS/MO = 1,089 one-way passenger boardings per month.

Table 4-3

PROCEDURE FOR CALCULATING TRAVEL DEMANDS ON INTERCITY BUS ROUTES WITH A CALCULATOR[1]

Use the equation for routes 20-120 miles long as an example:

$$PASS/MO = RTFREQ^{1.093} \times SERVPOP^{0.409} \times FARE/MI^{-0.352} \times 6.871$$

STEP 1	A: Enter round trip frequency per week B: Press y^x button C: Enter 1.093 D: Press = button E: Record answer
STEP 2	A: Enter population served along the route (number of persons divided by 100) B: Press y^x button C: Enter 0.409 D: Press = button E: Record answer
STEP 3	A: Enter fare in cents per mile B: Press y^x button C: Enter 0.352 D: Change sign to minus E: Press = button F: Record answer
STEP 4	Multiply 6.871 times answers to Step 1 times Step 2 times Step 3
STEP 5	Write down the result; this is the prediction of the number of one-way passengers per month on that particular route.

Note: This example has been developed using Sharp and Texas Instruments scientific calculators. The exact sequence of steps may be slightly different for calculators from other manufacturers.

Observations About the Bus Ridership Models

Results Should be Carefully Reviewed

As with all models, the user must carefully review the reasonableness of route-level ridership estimates. Ideally, estimated ridership on a route should be compared with actual ridership data, if available, for existing services. This will provide the user with an indication of applicability of the models in the corridor of interest.

In case study corridors for which actual operations data were available, the demand estimations were close to the actual ridership: the model estimated ridership within 35 percent of a reasonable control number (which was the greatest deviation from the expected values in the test group). This confirms the findings that the demand equations were quite satisfactory on routes under 120 miles in length and could also be used on longer routes if carefully tempered by the judgment of a planner or operator who is familiar with the area's characteristics.

Caveats Regarding the Use of Models Must be Recognized

The models performed well for all corridors, particularly those under 120 miles in length. However, the modeling techniques must be used with caution for routes that:

- involve significant levels of "overhead" (i.e., through) ridership;
- are longer than 120 miles; or
- have intensive intermodal competition.

The ridership models predict <u>route</u> (operator) level patronage within a service area of interest. They do not predict "overhead" ridership, which is the number of passengers riding on that route originating from or destined to points outside of that route. As such, the models tend to underestimate total ridership for a route. If estimates of overhead ridership are known, they should be added to ridership estimates produced by the models to obtain a total figure of the number of passengers on a bus.

The demand models were estimated on route (operator) demands, and as such the models should be applied on an operator-specific, not a corridor basis. Thus, in corridors with two or more operators, each operator's ridership should be estimated separately, and the individual riderships then summed to estimate corridor ridership. It is noteworthy that, in several of the equations, ridership is directly proportional to frequency, a further reason why ridership can and should be estimated on an operator-specific basis.

Routes over 120 miles in length must be analyzed with particular care. The model suitable for such routes was developed with a set of routes averaging approximately 150 miles in length. Therefore, this model should not be used on routes substantially longer than 150 miles. When analyzing longer routes, it will be necessary to segment the route in order to apply the model in a conceptually sound manner. Undoubtedly, this adds some error and uncertainty to the final ridership estimate, but this should not be a serious problem if the actual ridership of the route is known for comparison and calibration purposes.

In corridors where intense rail-bus or air carrier-bus competition exists, the models do not take this into account. This is not as serious a limitation as it may initially appear. In many rural areas, competition between these modes is limited due to the different populations served and different trip purposes served by each mode; in most instances, the nature of proposed changes in intercity bus service is such that it is unlikely to result in major shifts in existing modal splits.

Actual Ridership Will Vary from the Estimates

As with all estimating techniques, it must be remembered that, while the models are highly accurate overall, they may not be equally accurate in each specific application. Inevitably, the user must make a judgment of whether he or she is comfortable with these estimates for decision-making purposes. To help account for such risks, it is advisable to explore the implications of a $\pm$ 30 percent range about the estimated ridership. The analyst can use this range to assess the financial risks of under-or-over estimating ridership.

The Models Can be Applied in a Short Time

If a user has population data available by jurisdiction and an up-to-date set of intercity bus schedules, it should typically take one day to develop the inputs to and apply the ridership estimation procedures used in this analysis for the existing service. Once this is done, many service options can be analyzed within several hours of work.

Summary

A number of different modelling procedures were evaluated before recommending the approach described, but all others had significant problems. The only simpler methods would be to rely exclusively on professional judgment to estimate ridership. The models described, used for forecasting the demand for intercity bus services, can be useful in analyzing existing routes or planning services where none now exist.

ESTIMATING THE DEMAND FOR AIRLINE SERVICE

This section discusses several techniques that have been suggested to estimate demands for airline services for small urban and rural communities. While the models are not as advanced and do not provide as accurate estimates as do the intercity bus models, the models available do offer a possibility of initial numerical estimates.

Factors Associated with Demand[1]

Air service is heavily dependent on a number of local factors. All of the following conditions should be considered when analyzing the possibility of gaining or maintaining service.

Isolation

The degree of isolation of a city is a major factor in commuter airline use up to a certain point. The biggest factor in isolation is the distance to a hub airport, since the Regional Airline Association estimates that 70 percent of all regional airline passengers are traveling to or from hub airports. Isolation takes into account not just physical distance to a hub, but the

[1]Much of the information in this section is derived from William E. O'Connor. An Introduction to Airline Economics. Praeger Publishers, New York, 1982.

competing modes of transportation. Driving time, not just distance, must be considered. If travelers must go miles out of their way to cross a bridge, for instance, this would increase the relative isolation from a travel standpoint. Isolation alone, however, will not create demand for airline service. If a city is so isolated that it cannot attract a reasonable level of economic activity, then it is unlikely to attract air service.

Type of City

Another factor to be considered is the city type. Is it predominately manufacturing, commercial, tourist, or institutional? Other factors can blur this distinction, but as a rule it has been found that commercial cities tend to generate more traffic than manufacturing cities. Additionally, a 1976 survey of commuter passengers in Iowa found that over 80 percent of travelers were in professional, technical, or managerial positions.[1] Institutional cities (those with universities or major governmental functions) also tend to generate traffic. Tourist cities will generate traffic, but only a few small cities have enough tourist attraction to generate traffic for only that reason.

City Population

The size city needed to support air service is the most difficult variable to quantify. Some literature on commuter air service refers to cities with less than 10,000 people as small, but this is referring mostly to air taxi type service.[2] Other literature defines the medium-sized category as population between 10,000 and 100,000.[3] There are cities of 30,000 which are supporting profitable air service, and others of 45,000 which require several hundred dollar per passenger subsidies.

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[1]Bruce Thorson and Kenneth Brewer. "Model to Estimate Commuter Airline Demand in Small Cities." Transportation Research Record #673, Transportation Research Board, Washington, D.C., 1977, pp. 187-193.

[2]Ibid.

[3]Yupo Chan. "Airline Deregulation and Service to Small Communities." Transportation Research Record #851, 1982, p. 29.

More important than population is average daily passenger enplanements. Historically, the Civil Aeronautics Board believed that any community generating more than 40 passengers a day could support air service without subsidy.[1] Other estimates place this figure as low as ten enplanements a day.[2]

The next logical step is to attempt to link population and enplanements. The demand models below are broken into two categories. One is to be used where judgement would estimate below 15 enplanements a day, and the other where judgement would estimate above 15 enplanements a day. The developers of the model point out that accurate models are hard to design precisely because there are so many factors that influence the ability of a city to support service. Another problem is that, with the lack of regulation in the industry, solid information about travel patterns is hard to collect.

This model was used as the basis of a recommended program to integrate commuter air carriers into Iowa's total transportation system. The general format specifies that air passenger traffic is a function of the population of the community and its isolation. The model explains 40 percent of the variation in enplanements, and can be used to establish a general feeling for whether or not service is feasible.

If initial suppositions lead one to expect less than 15 enplanements a day, the formula to be used is:

$$ADPE = 3.04153 + .7312(POPL) + .206(ISOLATE)$$

where:

ADPE = Average Daily Passenger Enplanements

ISOLATE = Miles to the nearest FAA hub in tens

POPL = Population in thousands

If judgement estimates more than 15 enplanements a day, the formula is:

$$ADPE = 6.96 + .6183(POPL) + 1.36586(ISOLATE).$$

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[1]Abdussalam A. Addus. "Essential Air Service Determination for Small Communities." Transportation Quarterly, Vol. 39, No. 4, 1985, p. 537.

[2]Op. cit., Yupo Chan.

An alternative formulation has been provided by Pickrell.[1] Using the same kind of basic model, Pickrell postulates that the number of one-way air passenger trips on an individual route connecting a small community with a specific large- or medium hub city is a function of

- the population of the community in which those trips originate,
- the number of passenger enplanements at airports in the hub city at the route terminus,
- the published air fare for the trip,
- the scheduled flying time,
- the number of weekly departures from the origin community to the major destination city,
- the average seating capacity per departure,
- the estimated out-of-pocket cost for travel by auto for the trip,
- the estimated driving time for the trip, and
- whether or not the route is served by a certificated air carrier.

The largest influences in overall demand were flying time, the air fare, frequency of scheduled departures, and the volume of traffic at the hub airport. While the models produced with these variables generally showed intuitively correct results, the models could only account for less than half of the observed variation in passenger volumes along specific routes.

There are other methods of determining reasonable possibilities of successful service. Commuter airlines operated in 1985 with average load factors of 42-45 percent.[2] Since the types of aircraft being used by a regional airline serving any given area can be readily identified if reasonable estimates of average daily passenger enplanements can be generated, the level of service that can realistically be expected or supported can be estimated.

In addition to demand models, local travel agents are an excellent source of information on local travel patterns. Travel agents, obviously, seldom report their sales on a disaggregate basis, but if they can be convinced that long-term gains are possible by revealing figures for total ticket sales, some information may be forthcoming. If all of the travel agents participate, a

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[1]Don H. Pickrell. "The Demand for Short-Haul Air Service." In John R. Meyer and Clinton V. Osker, Jr., Deregulation and the New Airline Entrepreneurs, Cambridge, The MIT Press, 1984.

[2]Regional Airline Association. Annual Report, Washington, D.C., 1986.

reasonable figure in a city for the total dollar volume of airline ticket purchases in a community can be generated. If the figure is large enough that even a small fraction of it would represent a sizable market, a regional airline might be induced to more closely examine the feasibility of service.

Airline Planning

As mentioned above, the lack of information on the internal planning process of the regional airlines has frustrated local planners and academics alike. A 1984 study attempted to uncover and document some of these methods.[1] It discovered that decisions about which communities to serve are made at the top levels of the companies. Presidents and executive vice presidents seemed to be involved in most of these decisions. Marketing also played an important role in this selection at one-third of the airlines surveyed. The planning horizon of commuter airlines tends to be relatively short. Sixty percent of the airlines decided which communities to serve less than six months before implementing service. Another 35 percent selected communities six months to one year prior to beginning service. Regional airlines relied primarily on FAA and DOT airport and carrier statistics, the actions of competitors, and passenger surveys for information when making service decisions. Consultants were used about one-third of the time when making these decisions. Sixty-seven percent of the airlines did have policies for establishing if a community would be served, and 50 percent of the airlines did use computer techniques in making these service decisions. As would be expected, the sophistication of the planning techniques increased as the size of the airline grew.

This information about the airline planning process regarding service decisions may be useful to local groups supporting increased air service. It suggests that:

- Information about the community and its commitment to use the service should go to the very top level of airline management.
- Offers of local marketing activities may be persuasive in attracting carriers.

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[1]Lawrence Cunningham, Kenneth Williamson, and Wallace Wood. "Planning Decisions in Commuter Airlines." Transportation Journal, Vol. 23, No. 3, 1984, p. 53.

- Community air service groups should make efforts to find out what policy requirements potential carriers may have regarding service decisions. Local groups can then determine whether they meet airline requirements, and if local actions could help qualify the area to receive more service.

- Local groups need to be prepared to provide their supporting activities quickly, given the short periods of time which elapse between decisions to implement service and the actual inauguration of flights.

Another factor influencing regional airline service planning decisions is the growth in marketing alliances with major carriers. These often include "code sharing" arrangements with major carriers.[1] Under these agreements, regional carriers are listed in the computer reservations system (which are owned by the major carriers) as if they are part of the larger airline. Interline ticketing, joint use of terminals, use of the major carriers' name and corporate trademarks, and joint marketing are usually part of these agreements as well. This combination of regional and major carriers is likely to appear as one single corporate entity.

There are several ways in which "code-sharing" agreements affect service planning decisions that local groups may be attempting to influence. One is that the major airline partner is likely to have a strong say in service decisions such as whether or not to serve a community, frequency, type of equipment used, and fares. Such decisions will likely be oriented toward the development of the regional services as complementary "spokes" feeding the major carrier's "hub". This makes the regional carrier into a more effective connection to the national airline service network.

A second way in which "code-sharing" agreements affects small community air service is a tendency for the affiliated regional carriers to replace the services of their major carrier marketing partner in city-pair markets whose volumes are too small to support major carrier jet service.[2] While communities often perceive such changes as a decrease in quality of service (due to the use of smaller aircraft), it is usually beneficial in that the connecting service is continued, and often at higher frequencies.

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[1]Don H. Pickrell and Clinton V. Oster. A Study of the Regional Airline Industry -- The Impact of Marketing Alliances. U.S. Department of Transportation, May 1986, pp. 17-30.

[2]Ibid., pp. 27.

Another potential benefit from regional airline marketing alliances can be reductions in fare levels resulting from joint fares established between the major and regional carriers involved in the alliance. These are often lower than the sum of an independent regional airline's fare and that of a major carrier. In effect, the major carrier may be subsidizing regional air service from smaller communities to its hubs in order to increase its market share on the trunk routes between hubs. Groups involved in trying to improve air service to small cities may want to consider the fare impacts of different fare arrangements as they try to attract new carriers or services to their towns.

USES AND LIMITATIONS OF PROCEDURES FOR ESTIMATING DEMAND

The demand models are intended to provide "sketch planning" or order of magnitude estimates for specific intercity routes serving small urban areas and rural areas. These techniques provide a reasonably simple, low cost, quantitative basis for developing initial demand estimates for evaluating the costs and benefits of existing and proposed services. For example, potential uses for such models include:

- comparing ridership potential on many routes serving small urban areas in order to identify those that might warrant further analysis and consideration;
- checking the reasonableness of ridership projections developed by other government agencies and companies if state DOT financial support is being sought for such services; and
- assessing potential changes in ridership if different types and levels of services were operated on a route.

A model's estimates should provide those using them with a "sense" of the ridership potential of specific routes. More refined ridership estimates for decision-making should be developed based on assessments of the socioeconomic and other characteristics of the travel market served and the service characteristics of the proposed or existing route.

The demand models have a number of limitations. Potential users must be aware of these limitations and must account for them in their use of the models. As noted above, the models provide "sketch planning" type estimates, not highly refined estimates for every conceivable service design or route under consideration. This is the case for several reasons. First, the formulations of the demand models are relatively simple and do not include all potentially important variables (e.g., auto ownership, intermodal competition) that would produce a fully specified model. However, while not including all possible variables, the models appear to be sensitive to the key demographic and service characteristics that affect ridership.

Second, the models are based on cross-sectional data (i.e., data for a single point in time), not time-series data. While the use of time-series data for model development is desirable, such data are seldom available on a route basis. Unfortunately, this is a limitation of virtually all travel demand models used in intercity transportation planning.

Third, the models are applicable to fixed route, fixed schedule type of intercity services, not to variable route or variable schedule types of service.

Fourth, an important limitation of any empirical model -- including these -- is the implicit assumption that services and responses in those systems being estimated are essentially similar to those systems for which the models were developed. Thus, any radically new type of service -- such as intercity services provided on flexible schedules or routes by jitneys or car pools -- would not necessarily fit within the models developed. Similarly, the models do not necessarily apply to routes whose statistics are very different from the mean values of the routes used to develop these models or to other competing modes.

With these caveats in mind, planners and decision-makers should proceed to apply these or similar models. Despite their limitations, they do provide reasonable methods of making initial estimates of demands which will be useful in certain service decisions.

5

COSTS AND BENEFITS OF RURAL INTERCITY TRANSPORTATION PROJECTS

The key question for officials and planners concerned about maintaining rural intercity bus, rail, and air services is whether or not the service is sufficiently important to warrant public intervention and investment. One of the major benefits of regulatory reform is that it created strong incentives for private carriers to move their resources from unprofitable activities to areas where additional investments would produce profits. Thus the services that are subject to abandonment are usually those with low demand and little apparent prospects for increased revenues. Clearly, not all such cases will be worthy of public assistance, and, if public intervention and investment is contemplated, a method must be employed to make sure that the public benefits exceed the costs. In addition, when there are many potential projects that are worthy of public support and resources are scarce, a means of ranking the projects must be used to ensure the maximum public benefit.

Cost-benefit analysis is the technique that economists have developed to measure the public benefits, compare them to the costs, and assess the value of a particular project or a program of projects. In rural transportation, it has been applied most rigorously with regard to branch rail line projects for purchase and rehabilitation. Operating projects, such as operating subsidies for rural intercity bus service, have rarely been subjected to a cost benefit analysis, but rather have been evaluated in terms of needs or revenue/cost ratios. This chapter illustrates cost-benefit analysis with two applications:

a rail branch line cost-benefit analysis as an example of an evaluation of a capital project, and a cost-benefit analysis of operating subsidies for rural intercity bus service.[1]

Both applications reveal that benefits vary with usage, and that services that are heavily utilized are those most deserving of assistance. High usage, low-cost projects should be favored, for the most part. Therefore, good estimates of cost, and reasonable, accurate predictions of actual usage are needed to make the cost benefit analysis valid. Suggested methods of determining cost and demand have been discussed in previous chapters; this chapter integrates those components into the overall cost-benefit methodology.

BENEFIT-COST ANALYSIS OF A CAPITAL PROJECT: RAIL BRANCH LINES

Introduction

Cost-benefit analysis of local rail service projects was mandated by the Local Rail Service Assistance Act of 1978 for all projects to become eligible for Federal funding. Such projects could include acquisition, rehabilitation, new construction, or replacement service. While the availability of Federal funding programs for such purposes has declined, the planning techniques developed for them remain valid for use by states, localities and other groups. A number of state funding programs for rail also require such analyses. While the method presented here deals basically with capital investments in rail branch lines, it can be adapted to other investments such as airport construction or improvements or investments in barge or ferry service.

As indicated above, the object of benefit-cost analysis is to determine whether the benefits of a proposed project, in this case a rail project, are greater than the costs. A ratio -- the benefit/cost ratio -- is computed for each project alternative, by dividing the expected benefits by the expected costs. A ratio greater than one means the project is generally considered to be worth doing, while a ratio with a value less than one means that it should not be done unless there are some other non-monetary reasons (for example, national defense). Not all projects with ratios greater than one will be

[1]No air service cost-benefit method is included, though it would be useful to have such a tool. There are a number of different techniques for examining the costs and benefits of airport investment and operations, but under the Federal Essential Air Service Program, no such examination has been required of small city air service. As states and localities do not generally subsidize air service, there have been few, if any, recent efforts to perform such analyses.

implemented, as resources are scarce. Ranking projects by their benefit-cost ratio is one way of determining which projects are most worthwhile.

The methodology presented in this section is adapted from the Wisconsin State Rail Plan 1983 Update, prepared by the Wisconsin Department of Transportation, Division of Planning and Budget. Wisconsin, in turn, used a streamlined version of the principles contained in a Federal Railroad Administration report entitled Benefit-Cost Guidelines, Rail Branch Line Continuation Assistance Program, as the basis for the methodology. It is a classical cost-benefit formulation, and is being presented here only in its most basic form.

Assumptions of the Analysis

Skill of the Analyst

While the material presented here is intended for general audiences, it should be recognized that to actually perform the kinds of calculations described below, some skill in economics or mathematics would be desirable. Persons with the skills needed for these analyses can often be found in state departments of transportation, as well as in other planning or economic development offices.

Geographic Scope of the Analysis

One of the first steps in the cost-benefit analysis is determining the perspective of the analysis -- local, county, state or Federal -- because the impacts of alternatives may be different at each level when all the possible offsetting factors are included. For example, a job lost in one local area due to rail abandonment may be offset by a new trucking job in another area of the state. In most states, the funding for rail assistance projects has come from either Federal or state sources, which would argue for including most of these offsetting impacts in other geographic areas. However, the goals of the program are to preserve local rail service, and so a local perspective should also be included. In the state of Wisconsin, a county-level perspective was chosen as the basis of ranking the projects.

Discount Rate and Term of the Project

The term of the project and the discount rate chosen to value future streams of income can make the major difference in the analysis. Ideally, these values are objectively determined, based on the real rate of interest and the engineering life of the project being built. The real rate of interest should be considered as the rate net of the expected inflation. For example, if inflation is anticipated to be six percent per year, and market interest rates are 11 percent, the real interest rate (which represents the opportunity cost) would be five percent.

Wisconsin chose 20 years as the term of rail projects, unless it was known that the particular improvement would have a shorter useful life. The 20-year period was chosen as the expected life of track, ties, and structures with normal maintenance levels.

Project Type

Project type refers to the expected result of the project, as the method of analysis varies somewhat according to the elements to be included as costs and benefits. Wisconsin developed four categories of projects:

- Continuation of Rail Service -- Capital improvements are needed to allow rail service to continue. Without the investment, all shipping will have to move by truck.
- Improvements in Operating Speed -- Investment is needed to improve rail speeds from current levels to faster service.
- Advance Capital -- Investment is needed now to avoid probable future abandonment.
- Substitute Service -- Investment is needed in facilities to allow shippers to use alternative modes to reach the nearest railhead not on the branch.

The costs and benefits to be included in the analysis for each type of project are listed in Table 5-1.

General Formulas for Computing Cost-Benefit Ratios and Net Present Value

The general formulas for computing cost-benefit ratios and net present value are presented below. As indicated earlier, a cost-benefit ratio greater than one means the gains outweigh the costs. The net present value is the amount by which the benefits exceed the costs. Both values are discounted

Table 5-1

COSTS AND BENEFITS BY PROJECT TYPE

Group 1 Projects -- Continuation of Rail Service at Specified Levels

1. Benefits

   a. The net difference in cost of providing rail service versus the cost of trucking, i.e., truck cost minus rail cost.

   b. Net wage losses if it is physically impossible to ship a certain commodity by truck, resulting in a shipper/receiver going out of business or reducing operations.

   c. The discounted salvage value of the facilities at the end of the project's life.

2. Costs

   a. Purchase price of land and track.

   b. Rehabilitation costs to stabilize a line so that normal annual maintenance can be made to keep the line at an appropriate standard.

   c. New connections or other facilities required of the basic operation.

Group 2 Projects -- Improvements in Operating Speed[1]

1. Benefits

   a. Decreases in operating cost such as reduced cost of derailments, reduced labor costs, reduced hotel and meal allowances, reduced fuel costs, and reduced car hire costs.

   b. The discounted salvage value of the improvements made by the project.

2. Costs -- Rehabilitation to speeds higher than FRA Class One (lowest) track Quality

[1]Ordinarily, Group 1 calculation of the net present value at the "before" speed and the "after (repair)" speed is used to indicate whether expenditures to permit increased operating speed are justified. Where land, track and trucking costs are unavailable, then this Group 2 method may be used.

Table 5-1 (continued)

Group 3 Projects -- "Advance Capital"

1. Benefits

   a. The net difference in cost of providing rail service versus the cost of trucking, but multiplied by the estimated probability of rail abandonment in a given year. This is the same as Group 1 benefits, except for the probability element.

   b. Decreases in operating cost such as reduced cost of derailments, reduced labor costs, reduced hotel and meal allowances, reduced fuel costs, and reduced car line costs. This is the same as Group 2 benefits.

   c. The discounted salvage value of the facilities at the end of the project's life.

Group 4 Projects -- Substitute Service

1. Benefits

   a. The difference in cost of trucking to alternative railheads, (i.e., cost before project minus cost after project)

   b. Decreases in loading/unloading costs

2. Costs

   a. Cost of team track facilities

   b. Cost of transloaders

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over the life of the project to account for the fact that future income is worth less than today's income. Both costs and benefits are discounted, as can be seen in the formulas. The formula for benefit-cost ratio is:

$$BCR_k = \frac{\sum_{j=1}^{n} \left[B_{kj} \quad \frac{1}{(1 + i)^j} \right]}{\sum_{j=1}^{n} \left[C_{kj} \quad \frac{1}{(1 + i)^j} \right]}$$

where

BCR_k = benefit-cost ratio of project k

B_{kj} = benefits from project k in year j

C_{kj} = costs of project k in year j

$\frac{1}{(1+i)^j}$ = present worth discount factor at rate of discount i for jth year

$\sum_{j=1}^{n}$ = sum over n periods of years.

The benefit-cost ratio, while extremely useful, is not the best way of ranking projects that all have a positive ratio. This is because it is entirely possible that a small project will have a very high benefit-cost ratio but produce small dollar benefits, while other projects with lower ratios actually produce more benefits for the same amount invested. Thus it is advisable to calculate the net present value of each alternative, and rank them from the highest net benefit to the lowest. Under a budget constraint, the projects with the highest rank are chosen, until the available funds are exhausted. The formula is:

$$NPV_k = \sum_{j=1}^{n} \left[(B_{kj} - C_{kj}) \quad \frac{1}{(1 + i)^j} \right]$$

where

NPV_k = Net Present Value of project k.

Example calculations using these formulas are included in Tables 5-2 through 5-5, each one representing a different type project. These examples are from the Wisconsin report.

Incremental Comparisons

In some cases, different alternatives for a particular project may consist of incremental improvements to a line. For example, one alternative (B_0) may be the minimum track work to retain service, with alternative B_1 the additional improvements to allow higher speed service. In such cases the benefits and costs of the additional increment must be properly accounted for by substituting the difference in benefits and the difference in costs into the formulas for the benefit-cost ratio and net present value as follows:

Substitute $(B_1 - B_0)$ for B,

where

B_1 = Benefits of alternative being evaluated

B_0 = Benefits of next lower cost alternative; and

Substitute $(C_1 - C_0)$ for C,

where

C_1 = Costs of alternative being evaluated

C_0 = Costs of next lower cost alternative.

In general, the alternative with the highest net present value should be chosen, assuming all have cost-benefit ratios greater than one.

For rail freight service the cost-benefit approach presented here uses trucking costs as the primary benchmark against which savings due to continuation or improvement of rail service can be compared. However, the complete list of alternatives evaluated should probably include:

TABLE 5-2

EXAMPLE BENEFIT-COST COMPUTATION FOR GROUP ONE PROJECT

ACQUISITION AND REHABILITATION

	BENEFITS			COSTS		
1	2	3	4	5	6	7
Year	Efficiency Benefits	6% Discount Factor	Benefits (2) x (3)	Initial Land & Track Value	Rehabilitation	Discounted Rehabilitation (3) x (6)
1	$120,000	0.94	$ 113,208	$240,000	$1,200,000	$1,132,075
2	120,000	0.89	106,800		0	0
3	120,000	0.84	100,754		0	0
4	120,000	0.79	95,051		0	0
5	120,000	0.75	89,671		0	0
6	120,000	0.70	84,595		0	0
7	120,000	0.67	79,807		0	0
8	120,000	0.63	75,289		0	0
9	120,000	0.59	71,028		0	0
10	120,000	0.56	67,007		0	0
11	120,000	0.53	63,215		0	0
12	120,000	0.50	59,636		0	0
13	120,000	0.47	56,261		0	0
14	120,000	0.44	53,076		0	0
15	120,000	0.42	50,072		0	0
16	120,000	0.39	47,238		0	0
17	120,000	0.37	44,564		0	0
18	120,000	0.35	42,041		0	0
19	120,000	0.33	39,662		0	0
20	120,000	0.31	37,417		0	0
			$1,376,391		$1,200,000	$1,132,075

Salvage Value of Project	
Current Market Value	$ 240,000
Addition to Value Due to Rehab	283,019
Total Salvage Value	$ 523,019
Discount Factor at End of Project Life	.312
Discounted Salvage Value	$ 163,182

Benefit-Cost Ratio and Net Present Value	
Discounted Efficiency Benefits	$1,376,391
Discounted Salvage Value	163,182
Total Benefits	$1,539,572
Initial Value	$ 240,000
Discounted Rehabilitation	1,132,075
Total Costs	$1,372,075
Benefit-Cost Ratio	1.12
Net Present Value	$ 167,497

TABLE 5-3
EXAMPLE BENEFIT-COST COMPUTATION
FOR GROUP TWO PROJECTS

CLASS TWO REHABILITATION

BENEFITS				COSTS			
1	2	3	4	5	6	7	8
Year	Class 2 Efficiency Benefits	6% Discount Factor	Discounted Class 2 Benefits (2) x (3)	Rehabilitation to Class 2	Rehabilitation To Class 1	Net Class 2 Rehabilitation (5) - (6)	Discounted Class 2 Rehabilitation (3) x (7)
1	$205,120	0.94	$ 193,509	$550,514	$ 400,000	$ 150,514	$ 141,994
2	205,120	0.89	182,556	880,214	0	880,214	783,387
3	205,120	0.84	172,223	880,214	0	880,214	739,045
4	205,120	0.79	162,474	880,214	0	880,214	697,212
5	205,120	0.75	153,278		0	0	0
6	205,120	0.70	144,602		0	0	0
7	205,120	0.67	136,417		0	0	0
8	205,120	0.63	128,695		0	0	0
9	205,120	0.59	121,410		0	0	0
10	205,120	0.56	114,538		0	0	0
11	205,120	0.53	108,055		0	0	0
12	205,120	0.50	101,938		0	0	0
13	205,120	0.47	96,168		0	0	0
14	205,120	0.44	90,725		0	0	0
15	205,120	0.42	85,589		0	0	0
16	205,120	0.39	80.745		0	0	0
17	205,120	0.37	76,174		0	0	0
18	205,120	0.35	71,863		0	0	0
19	205,120	0.33	67,795		0	0	0
20	205,120	0.31	63,957		0	0	0
			$2,352,710		$ 400,000	$2,791,156	$2,361,638

Salvage Value of Project	
Addition to Value Due to Rehabilitation	$ 590,410
Discount Factor at End of Project	.312
Discounted Salvage Value	$ 184,208
Benefit-Cost Ratio and Net Present Value	
Discounted Efficiency Benefit	$ 2,352,710
Discounted Salvage Value	184,208
Total Benefits	$ 2,536,918
Discounted Rehabilitation	$ 2,361,638
Total Costs	$ 2,361,638
Benefit-Cost Ratio	1.07
Net Present Value	$ 175,280

TABLE 3-4

EXAMPLE BENEFIT-COST COMPUTATION FOR GROUP THREE PROJECTS

ADVANCE CAPITAL

Rehabilitation Element

BENEFITS						COSTS		
1	2	3	4	5	6	7	8	9
Year	Efficiency Benefits	Probability of Abandonment	Probable Benefits (2) x (3)	6% Discount Factor	Discounted Probable Benefits (4) x (5)	Initial Land & Track Value	Rehabilitation	Discounted Rehabilitation (5) x (8)
1	$100,000	.1	$10,000	0.94	$ 9,434	$500,000	$500,000	$471,698
2	100,000	.2	20,000	0.89	17,800		0	0
3	100,000	.5	50,000	0.84	41,981		0	0
4	100,000	.5	50,000	0.79	39,605		0	0
5	100,000	.5	50,000	0.75	37,363		0	0
6	100,000	.9	90,000	0.70	63,446		0	0
7	100,000	.9	90,000	0.67	59,855		0	0
8	100,000	.9	90,000	0.63	56,467		0	0
9	100,000	.9	90,000	0.59	53,271		0	0
10	100,000	.9	90,000	0.56	50,256		0	0
11	100,000	.9	90,000	0.53	47,411		0	0
12	100,000	.9	90,000	0.50	44,727		0	0
13	100,000	.9	90,000	0.47	42,196		0	0
14	100,000	.9	90,000	0.44	39,807		0	0
15	100,000	.9	90,000	0.42	37,554		0	0
16	100,000	.9	90,000	0.39	35,428		0	0
17	100,000	.9	90,000	0.37	33,423		0	0
18	100,000	.9	90,000	0.35	31,531		0	0
19	100,000	.9	90,000	0.33	29,746		0	0
20	100,000	.9	90,000	0.31	28,062		0	0
	$2,000,000		$1,530,000		$799,363		$500,000	$471,698

TABLE 5-4 (continued)

SUMMARY - GROUP 3

Salvage Value of Project	
Current Market Value	$500,000
Addition to value Due to Rehabilitation	125,000
Total Salvage Value	$625,000
Discount Factor At End of Project Life	.312
Discounted Salvage Value	$195,000

BENEFIT-COST RATIO AND NET PRESENT VALUE

Benefits	
Discounted Efficiency Benefits	$799,363
Discounted Salvage Value	195,000
Total Benefits	$994,363
Costs	
Initial Project Costs	$500,000
Discounted Rehabilitation	471,698
Total Costs	$971,698
Benefit-Cost Ratio	1.02
Net Present Value	$ 22,665

TABLE 5-5

EXAMPLE BENEFIT-COST COMPUTATION
FOR GROUP FOUR PROJECTS

SUBSTITUTE SERVICE

	BENEFITS			COSTS		
1	2	3	4	5	6	7
Year	6% Efficiency Benefits	Discount Factor	Discounted Benefits (2) x (3)	Initial Value	Rehabilitation	Discounted Rehabilitation (3) x (6)
1	$24,000	0.94	$22,642	$20,000	$10,000	$ 9,434
2	24,000	0.89	21,360		5,000	4,450
3	24,000	0.84	20,151		0	0
4	24,000	0.79	19,010		0	0
5	24,000	0.75	17,934		0	0
6	24,000	0.70	16,919		0	0
7	24,000	0.67	15,961		0	0
8	24,000	0.63	15,058		0	0
9	24,000	0.59	14,206		0	0
10	24,000	0.56	13,401		0	0
11	24,000	0.53	12,643		0	0
12	24,000	0.50	11,927		0	0
13	24,000	0.47	11,252		0	0
14	24,000	0.44	10,615		0	0
15	24,000	0.42	10,014		0	0
16	24,000	0.39	9,448		0	0
17	24,000	0.37	8,913		0	0
18	24,000	0.35	8,408		0	0
19	24,000	0.33	7,932		0	0
20	24,000	0.31	7,483		0	0
			$275,278		$15,000	$13,884

Salvage Value of Project	
Current Market Value	$ 20,000
Addition to Value Due to Rehabilitation	3,750
Total Salvage Value	$ 23,750
Discount Factor At End of Project Life	.312
Discounted Salvage Value	$ 7,410
Benefit-Cost Ratio and Net Present Value	
Discounted Efficiency Benefits	$275,278
Discounted Salvage Value	7,410
Total Benefits	$282,688
Initial Value	$ 20,000
Discounted Rehabilitation Cost	13,884
Total Costs	$ 33,884
Benefit-Cost Ratio	8.34
Net Present Value	$248,804

- not shipping -- that is, closing the business,
- trucking inputs and outputs to and from the nearest transloading point on the rail network, following abandonment, plus the cost of the line-haul on the rail,
- piggyback or container shipment, using trucks where most advantageous to reach intermodal terminal locations, or deliver at the other end, or
- trucking inputs and outputs the entire length of the trip.

In recent years, regulatory reform in the trucking industry and new flexibility for private carrier trucking have offered a wide range of rate discounting and special contract opportunities. For that reason, firms specializing in rates should be contacted to estimate the trucking cost alternatives for use in this analysis, rather than relying on a simple model which may not reflect the variation in rates now permitted. To account for the possibility that some discount trucking rates may not be sustainable, sensitivity tests on the benefits and costs of the rail alternative can be conducted using trucking rates increased by ten percent, 20 percent, or more. If the viability of the rail project is greatly improved by slight truck rate increases, it may be worthwhile to investigate the trucking costs in greater detail.

COST-BENEFIT ANALYSIS OF RURAL INTERCITY BUS SERVICE

This section examines the costs and benefits of subsidizing rural intercity bus service. Many persons see benefits of rural service that are not reflected in the revenues these services generate, and would therefore seek subsidies to maintain rural and small town service. As in the case of rail service, the justification for such subsidies needs to be examined, both in a general sense and for any particular route or service.

A number of rationales have been advanced for supporting intercity bus service in rural areas. One is that the overall welfare loss of bus users may be greater if service is abandoned than the subsidy required to maintain the service. Another is the possibility that if a bus service is abandoned, the auto would be the only alternative available in rural areas. However, many bus users have low incomes and are unable to afford automobiles or alternative transportation modes. It is also often suggested that the loss of bus service may have detrimental effects on the viability of the economy of small towns or rural areas, particularly since no other public transportation mode serves most small cities. A systematic means of examining these suggestions is needed if the subsidy question is to be adequately addressed.

Cost-benefit analysis is an appropriate means for accomplishing such an examination. A ranking of two economic conditions is sought: continued provision of rural bus service as against the abandonment of that service, where continuation implies subsidy. Cost-benefit analysis is in effect a calculation of the gains and losses that permits society to see whether or not a given change results in an overall improvement or loss.

Two approaches have been developed and applied to this problem. In North Carolina, a cost-benefit approach was developed and applied to several rural intercity bus routes. It used consumer surplus as the major component of user benefits. A second approach was developed recently by researchers in Wisconsin. They developed a model for estimating user benefits by creating a disutility value, which includes the time, money, and convenience factors affecting travel choices by users. These are calculated for all the trips being taken on a particular bus route, and then compared to the same costs if the trips had been taken by auto, or by a combination of auto (to the nearest bus stop) and bus. These approaches and applications are each presented in the following sections.

Cost-Benefit Analysis of Bus Service Using Consumer Surplus

Consumer surplus is the compensating variation that consumers would pay over and above what they are currently having to pay in order to obtain the goods or services in question. In that sense, it is a measurement of the difference in benefits between what they are paying for and what they would pay. The definition of a compensating variation leads directly to the idea of consumer surplus as one of the direct benefits to be measured in the analysis.

Basically, in the case of the possible abandonment of a currently operating rural bus service, the costs and benefits can be placed into a few categories.

Benefits include the consumer surplus of those currently using the service and an amount equal to the price they pay to travel in time and bus fare. Externalities can be assumed as minimal in the rural case, as little traffic congestion exists in rural areas, and the number of people currently using a particular service is quite small compared to the total number of travellers. Thus, the other negative externalities associated with a switch to auto use would not be significant when compared to the total auto use. With externalities assumed not to enter the situation, and with the assumption that the bus is already running, and the benefits are those associated with continuation of service, the consumer surplus, time cost, and fare revenue can be defined.

The consumer surplus depends on the alternative form of transportation that the user would face if the service was abandoned. If the only alternative were the auto, which we will assume as the most likely and simple case, the difference between auto travel time cost and operating cost and the bus travel time and fare are necessary to measure the consumer surplus. Two possibilities exist. One is the case in which some proportion of the current users are able to transfer to the private auto if service is abandoned. The second case assumes all users would be unable to make the trip if bus service were discounted. In terms of a general formula, the total benefit to users (consumer surplus and revenue paid) is:

$$TB = (1/2)(N)(T_A + F_A - T_B - F_B)$$

where

TB = the total benefit, i.e., the total now paid plus the additional value to those travelling after abandonment

N = the number of passengers using the service

T_A = the auto time cost

F_A = auto cost

T_B = bus time cost

F_B = bus fare

1/2 = reflects the assumption that the demand curve is a straight line between these two points, and the consumer surplus lost is only the amount below the demand curve. This represents the case in which there is no transfer to the auto.

Alternatively, it can be assumed that a proportion of the current users are able to transfer to the auto, paying the auto cost. In this case, if the service were abandoned, trips made would fall but some proportion of the trips would be made by auto. While those no longer making the trip would save on time and fares no longer spent on the bus, they would lose a benefit equal to their loss of consumer surplus. Those now using the auto would be paying higher costs in total, possibly the sum of a lower time cost but a higher "fare". They do however, retain their consumer surplus. In this case, the total benefit is defined:

$$TB = (N)(T)(T_A + F_A - T_B - F_B) + (1/2)(N)(1-T)(T_A + F_A - T_B - F_B)$$

where T is the fraction of the total trips formerly made by bus now transferred to the auto.

An additional benefit is the revenue to the bus operator. This benefit would be lost in either case if the service were to be abandoned, and so represents a value of continuing the service. Revenue is calculated:

$$R = (N)(1 - T)(F_B)$$

where

N = ridership

T = proportion of trips transferable to the private auto

F_B = bus fare

R = fare revenue.

As for costs, the only cost that will be singled out after the netting of time and fare costs already covered will be the operating expense to the bus company for the service. In this example, we will use the average firm total cost per bus-mile times the number of bus-miles operated providing that service. However, data limitations in the example developed below have restricted this analysis to use average cost values taken from state regulatory reports. Bus operating costs are defined as

$$BC = AC\ (BM)$$

where

BC = bus cost

AC = average total cost per bus-mile

BM = total annual bus-miles operated in the service under analysis.

Combining all of the above, the net benefit of continuing service is:

$$NB = (N)(T)(T_A + F_A - T_B - F_B) + (1/2)(N)(1-T)(T_A + F_A - T_B - F_B) + (N)(1 - T)(F_B) - BC$$

This is the definition of net benefit that will be the basis for the following numerical example.

An Application of the Cost-Benefit Approach to Four Rural Bus Services

The costs and benefits defined in the previous section are applied to data for four rural bus services operated in the state of North Carolina in Table 5-6. The data used were developed as part of a general study of intercity bus service in that state, The North Carolina Intercity Bus Study[1], and, with the exception of Total Operating Expenses (Scheduled Service), were available from the annual report of each firm to the North Carolina Utilities Commission. Each of the four services is the total scheduled service provided by that carrier, a fact which greatly facilitated the collection of these data, as firms are not required to report revenues and expenses by route or schedule in their annual report. Table 5-7 presents the maximum amount of information about the bus service that can be gathered from secondary sources. Completely absent is any information about the current users. All that is known is that they take the specified number of trips at the fares and schedules shown, giving one point on the demand curve. It is assumed that the demand curve is a straight line passing through the price/demand point available from the

[1] Frederic D. Fravel. The North Carolina Intercity Bus Study. Prepared for the Public Transportation Division, North Carolina Department of Transportation, 1978.

Table 5-6

CASE ONE: NO TRANSFER TO AUTO, ALL TRIPS FORGONE (USING HIGH AUTO COST = $0.179 PER MILE)

	Schedule 1	Schedule 2	Schedule 3A (including 1/2 hr. bus wait time)	Schedule 3B (excluding 1/2 hr. bus wait time)	Schedule 4
Benefits (in dollars)					
1. Value of loss of benefit of trip to those not traveling after abandonment	1,566	13,900	17,709	43,457	17,999
2. Loss of revenue to bus company					
a. Passenger	1,079	12,429	33,568	33,568	16,135
b. Express	1,728	50,560	1,925	1,925	18,642
Subtotal	2,807	62,989	35,493	35,493	34,777
Total Benefit	4,373	76,889	53,202	78,950	52,776
Costs (in dollars)					
1. Total bus operating expense	-18,820	-51,788	-34,962	-34,962	-45,360
Net Benefit (Annual)	-14,447	+25,102	+18,240	+43,988	+ 7,417

CASE TWO: NO TRANSFER TO AUTO, ALL TRIPS FORGONE (USING LOW AUTO COST = $0.08 PER MILE)

	Schedule 1	Schedule 2	Schedule 3A (including 1/2 hr. bus wait time)	Schedule 3B (excluding 1/2 hr. bus wait time)	Schedule 4
Benefits (in dollars)					
1. Value of loss of benefit of trip to those not traveling after abandonment	496	1,623	-15,700	10,048	1,983
2. Loss of revenue to bus company					
a. Passenger	1,079	12,429	33,568	33,568	16,135
b. Express	1,728	50,560	1,925	1,925	18,642
Subtotal	2,807	62,989	35,493	35,493	34,777
Total Benefit	3,303	64,612	19,793	45,541	36,760
Costs (in dollars)					
1. Total bus operating expense	-18,820	-51,788	-34,962	-34,962	-45,360
Net Benefit (Annual)	-15,516	+12,824	-15,167	-15,167	- 8,600

Table 5-6 (continued)

CASE THREE: 54.3 PERCENT OF CURRENT BUS USERS SWITCH TO AUTO, REMAINDER FORGO TRIPS (USING LOW AUTO COST = $0.08 PER MILE)

	Schedule 1	Schedule 2	Schedule 3A (including 1/2 hr. bus wait time)	Schedule 3B (excluding 1/2 hr. bus wait time)	Schedule 4
Benefits (in dollars)					
1. Value of loss of benefit of trip to those switching to auto after abandonment	540	1,762	-17,050	10,912	2,153
2. Value of loss of benefit of trip to those not traveling after abandonment	227	742	- 7,175	4,592	906
3. Loss of revenue to bus company					
a. Passenger	1,079	12,429	33,568	33,568	16,135
b. Express	1,728	50,560	1,925	1,925	18,642
Subtotal	2,807	62,989	35,493	35,493	34,777
Total Benefit	3,574	65,493	11,268	50,997	37,836
Costs (in dollars)					
1. Total bus operating expense	-18,820	-51,788	-34,962	-34,962	-45,359
Net Benefit (Annual)	-15,246	+13,705	-23,694	+16,035	- 7,523

CASE FOUR: 54.3 PERCENT OF CURRENT BUS USERS SWITCH TO AUTO, REMAINDER FORGO TRIPS (USING HIGH AUTO COST = $0.179 PER MILE)

	Schedule 1	Schedule 2	Schedule 3A (including 1/2 hr. bus wait time)	Schedule 3B (excluding 1/2 hr. bus wait time)	Schedule 4
Benefits (in dollars)					
1. Value of loss of benefit of trip to those switching to auto after abandonment	1,701	15,107	19,232	47,194	19,575
2. Value of loss of benefit of trip to those not traveling after abandonment	716	6,357	8,093	19,860	8,237
3. Loss of revenue to bus company					
a. Passenger	1,079	12,429	33,568	33,568	16,135
b. Express	1,728	50,560	1,925	1,925	18,642
Subtotal	2,807	62,989	35,493	35,493	34,777
Total Benefit	5,224	84,453	62,818	102,547	62,589
Costs (in dollars)					
1. Total bus operating expense	-18,820	-51,788	-34,962	-34,962	-45,360
Net Benefit (Annual)	-13,596	+32,665	+27,856	+67,585	17,230

Table 5-7

DATA FOR SELECTED NORTH CAROLINA SCHEDULES

EASURE	SCHEDULE 1	SCHEDULE 2	SCHEDULE 3	SCHEDULE 4
nnual Passengers	250	4,134	50,239	10,300
verage Trip Length (Miles)	86.3	60.1	13.4	31.33
assenger-Miles (Estimated)	21,580	248,580	671,360	322,700
us-Miles	18,096	51,788	46,503	74,262
otal Operating Expenses (Scheduled Service)	$18,820	$51,788	$34,962	$45,360
Average Cost Per Bus-Mile	$1.04	$1.00	$0.75	$0.61
Total Regular Route Passenger Revenue	$1,079	$12,429	$33,568	$16,135
Average Revenue Per Ticket	$1.90	$3.00	$0.67	$1.09
Package Express and Newspaper Revenue	$1,728	$50,560	$1,925	$18,642
Total Regular Route Revenue	$2,807	$62,989	$35,493	$34,777
Net Profit (Loss) On Regular Route Service- Passenger and Package Express	($16,013)	$11,201	$531	($10,582)
Average Travel Time for Both Bus and Auto (Hours)	2:15	1:45	0:30	1:02
Average Speed Including Stops (MPH)	38.0	34.1	26.8	30.0
Value of Travel Time	$2.33	$1.80	$0.51	$1.07
Value of Additional ½ Hour Waiting Time for Bus	$1.025	$1.025	$1.025	$1.025
Average Auto Cost @ $0.08 Per Mile	$6.90	$4.81	$1.07	$2.50
Average Auto Cost @ $0.179 Per Mile	$15.45	$10.75	$2.40	$5.61

data. A second point is chosen arbitrarily. For Cases 1 and 2, it is assumed that the second point is the sum of time and operating costs for auto. In these cases, it is assumed that if the bus service were to be abandoned, all bus users would forego taking trips, as the price of the next most expensive alternative, the auto, is too expensive. A number of bus operators suggested during the course of the North Caorlina study that this was in fact the case, and that only those persons with no alternative means of transportation now ride rural buses. Ordinarily these could be called captive riders, and the market inelastic, leading to the solution of raising fares until the service was profitable. However, income restrictions on the users have been assumed here so that all users in Cases 1 and 2 would cease taking trips if bus service ended.

Cases 3 and 4 also require an arbitrary assumption about the demand curve. Surveys of intercity bus users (not just in rural areas) have been performed in Michigan, Wisconsin, and Oregon, among other states. The Wisconsin study[1] asked bus riders whether or not they would be able to make the trip they were on if bus service had not been available. Forty-five and seven-tenths percent said no, they would not have travelled on that trip if the bus had not been available. In the absence of any bus user survey data from the services under analysis in this example, it is assumed some 54.3 percent of bus users could transfer to the private auto if bus service were abandoned to illustrate the difference in net benefits if transfer to auto is possible.

Average travel time was developed from bus schedules, and was assumed the same for auto travel, as the buses are travelling between small towns on the same highways as the auto would. However, it was assumed that the bus user would spend an additional half hour waiting at either end of the trip. It would be logical to expand that notion and include the access and egress time and operating costs, but no data were directly applicable to the kind of rural service dealt with in this study.

Value of travel time was set at 25 percent of the Average Manufacturing Hourly Wage for North Carolina, $4.10. It was assumed on the basis of the hours of the schedules that no work or business trips were involved, and that all bus users were trading leisure time for in-bus time. Leisure time was valued at 25 percent of hourly wage, and value of time spent waiting was

[1] Wisconsin Department of Transportation. Intercity Bus Transportation in Wisconsin, Volume II, User Characteristics, December 1976.

set at 50 percent of the hourly wage. Wait time was assumed the same for each schedule and the value used as the cost was the same for each.

Costs of operating an automobile present a number of problems associated with the question of whether or not the proper comparison is with the marginal or total cost of auto operations. If one assumes that bus users would have to purchase autos to travel if bus service was abandoned, then the barrier to transfer is quite substantial. Two auto cost ranges are given to take account of either the possibility that the tranferring bus user would consider only the marginal costs such as fuel, oil, tolls, and parking, or would buy a new compact automobile, and operate at an estimated cost of 17.9¢ per mile.

No effects were included for contributory revenues of bus passengers changing to other services, or for the possibility that the labor and resources saved by abandonment have no alternative use, i.e., no opportunity cost.

Each case is marked, and is essentially self-explanatory. Two estimates were made for Schedule 3, one including the half-hour wait time cost, and the other not, on the basis that the bus operates not from station to station only, but picks up and delivers passengers all along its route, which is tailored to the demand. That difference often makes an appreciable difference in the Net Benefit.

Cases 1 and 2 face a different, lower, demand curve than Cases 3 and 4, and so are not directly comparable. Still, it appears that the difference in the two levels of auto cost have a greater effect on the outcome than did the difference in demand assumptions.

As can be seen by examining the tables, the social benefits of Schedule 3B increase from -$15,167 to $43,988 when the assumed auto cost is raised from $0.08/mile (Case 2) to $0.179 per mile (Case 1)). Yet the change in benefits when one assumes that some of the riders will transfer to the private auto is much less. Assuming the higher auto cost level, the benefits are $43,988 if all current users no longer travel following discontinuation of the service; and $67,585 if 54.3 percent of the users shift to autos and the remainder forgo their trips. The increase in benefits is due to the increase in transportation costs faced by those who must drive if bus service on this route is ended.

Data for Schedule 3 was from the Virginia Dare Transportation Company service between Norfolk, Virginia and Manteo, North Carolina. The majority of the ridership on the route consisted of persons traveling on 10-ride commuter tickets, picked up at flag stops, and then transported to work in the restaurants and hotels of the beach resorts. The assumption of a minimal waiting time for the bus was seen to be more appropriate, and so the Schedule 3B analysis was applied. Given the high auto cost estimate, benefits of $67,585 were seen as part of the justification for continuing UMTA Section 18 operating assistance in the amount of approximately $70,000 per year.

Estimating The Benefits of Bus Service Using a Disutility Function

The Wisconsin Department of Transportation sponsored a study by the University of Wisconsin-Milwaukee on the benefits of intercity bus service.[1] This presentation of the model and its application are based directly on the Wisconsin study. In this study, an indicator is developed to allow the characteristics of alternative modes of transportation to be compared on a similar basis. This is done by reducing the components of travel choice into a disutility value. The disutility of a trip is a combination of its time, cost, and convenience. For this project disutilities were calculated as follows:

$$DU_{ijm} = IV_{ijm} + (C_1)(OV_{ijm}) + (CT_{ijm}/C_2) + C3_m$$

where

DU_{ijm} = The disutility of a trip between town i and town j using mode m (measured in minutes)

IV_{ijm} = The in-vehicle time using mode m between town i and town j

OV_{ijm} = The out-of-vehicle time between town i and town j using mode m

CT_{ijm} = The cost of travel between towns i and j using mode m

C_1 = Out-of-vehicle time multiplier. This is used to represent the inconvenience of waiting, etc. 1 minute of OV time = C_1 minutes of IV time.

C_2 = The value of time, given in dollars/minute

$C3_m$ = The mode bias factor. This represents other negative aspects associated with travel using mode m, such as discomfort, in units of minutes

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[1]Eric R. Hansen, Edward A. Beimborn, et al. The Benefits of Intercity Bus Service. Prepared by the University of Wisconsin-Milwaukee for the Wisconsin Department of Transportation, October 1986, pp. 51-62.

In-vehicle time is the length of the trip divided by speed. Out-of-vehicle time is a fixed amount (different by mode) that represents the time it takes to pay for the cost of the trip and board a vehicle. The cost of the trip is either the bus fare for a bus trip or the product of the trip length and a given cost per mile for an auto trip.

For an intercity trip the total disutility of a trip is the sum of the disutilities of the access trip to a terminal, the terminal to terminal trip, and the egress trip from terminal to the destination. The benefits of a mode can then be represented by the difference in its disutility and the disutility of the next best choice. For instance, given the choice of bus or auto for traveling to and from another city, the benefits of the bus would be the net savings it provides over auto in terms of disutility. For this analysis intercity bus transportation was compared only to the automobile and other intercity bus services.

Certain parameters must then be assumed for the disutility equation. The parameters or actual numbers used in the equation to calculate the benefits or disbenefits of a particular transportation mode. The parameters for which values must be assumed or developed include: out-of-vehicle time weight, value of time, mode bias factor, length of trip, access distance, relative speed (bus vs. auto), relative cost (bus vs. auto), and degree of captive ridership.

General Scenario

In order to examine the relative benefits of intercity bus travel and auto travel, a general scenario was established. The scenario assumes an intercity bus route was in existence between town i and j (Figure 5-1) but has been discontinued. Individuals wishing to travel from town i to town j have two choices: to travel by auto to their destination (an auto trip) or to travel to the nearest bus station (town x) with a connection to town j and then take an intercity bus to town j. When travelers reach the terminal in town j they complete the trip to their destination by local travel. This second type of trip is referred to as an auto-bus-auto trip (ABA).

The disutility of the bus trip and ABA trips as given by the basic equation but need to be modified to include the disutility of the bus trip itself plus the disutility of the access trip to the bus station in town i

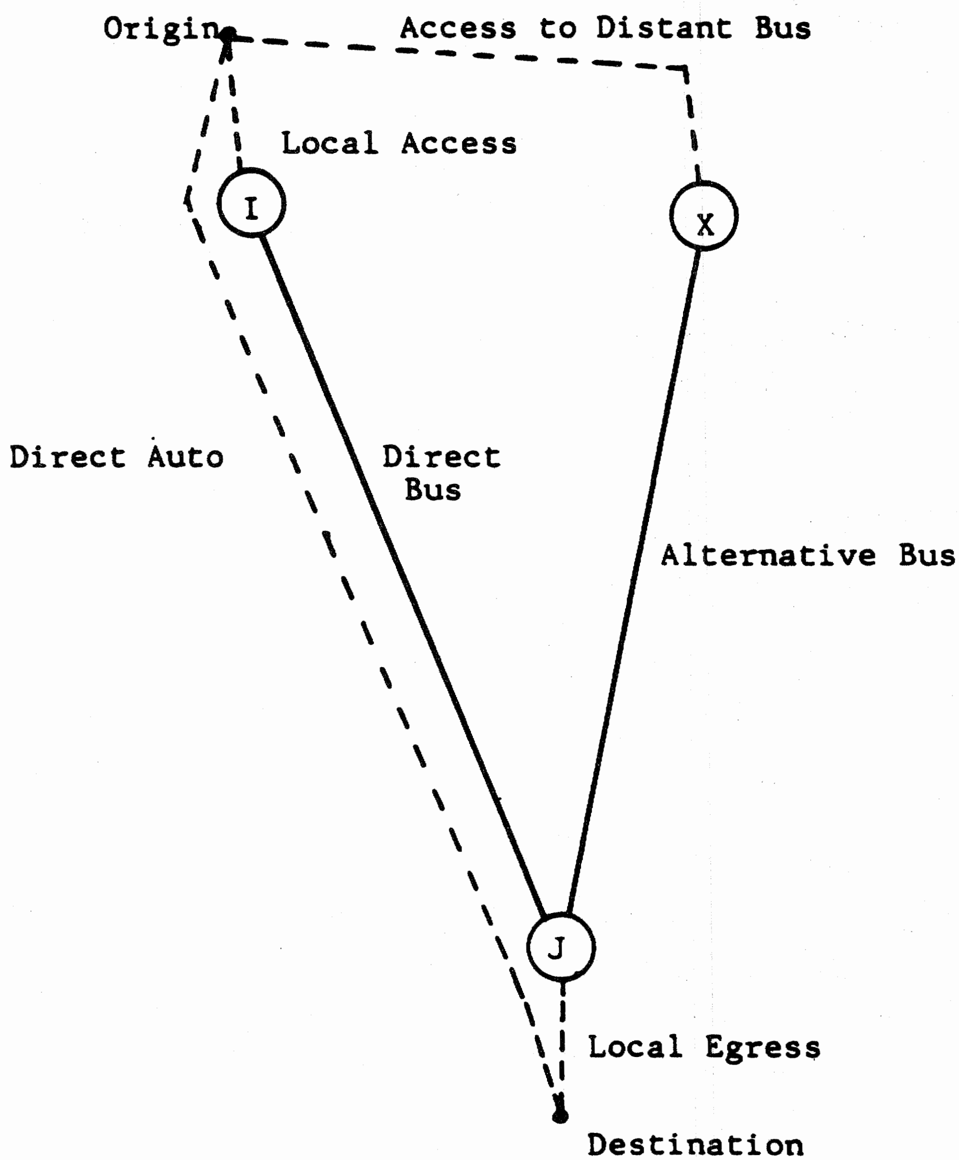

Figure 5-1: GENERAL CASE STUDY

plus the disutility of the egress trip from the terminal to the destination in city j. This is calculated as follows:

Bus service between i and j

$$DUB = A_{oi} + B_{ij} + E_{jd}$$

Bus service between x and j

$$ABA = A_{oi} + A_{ix} + B_{xj} + E_{jd}$$

where

DUB = Disutility of a bus trip between an origin in city i and a destination in city j.

ABA = Disutility of an ABA using a terminal in town x.

A_{oi} = Access disutility between origin and a terminal in town i.

A_{ix} = Disutility of travel between town i and town x.

B_{ij} = Bus service disutility between terminals.

E_{jd} = Egress disutility between terminal in destination city and final destination.

The disutilities A, B, and E are each calculated by the formula at the beginning of this section to include in-vehicle, out-of-vehicle, cost and mode bias components.

The calculation of auto disutility is similar in that it also includes local access components in the origin and destination cities. The all-auto trip has three components of in-vehicle time (for local driving at the origin city, for city to city travel and for local driving in the destination city), and single out-of-vehicle time, cost and mode bias coefficients. The disutility of an auto trip is as follows:

$$ADU = (IV_{oi} + IV_{ij} - IV_{jd}) + C_1 \, (OV_{oi}) + (CT_{od}/C_2) + C_3$$

The terms of this equation are the same as those given in the equation at the beginning of the section. The disutility of an auto trip is further modified to account for captive users. If a person is a captive user (i.e., unable to use an automobile), it is assumed that the disutility of the automobile portion of the trip would double to account for the disutility of the person who drives the captive bus user to the destination or to the terminal. The disutility of the driver is double because only one-way trips from town i and to town j (and not the return trip) are considered.

The disutility of an auto trip is then its disutility as given above plus the disutility multiplied by the percent captive users to represent these second trips. Thus, since the cost of travel is still paid only once for a vehicle, this is subtracted from this total. The disutility of an auto trip is then:

$$DUA = ADU_{ij} + (PC)\ (ADU_{ij} - CT_{od}/C2)$$

where:

- PC = The portion of users who cannot use an automobile for the trip
- ADU_{ij} = The disutility of the auto trip between town i and town j
- CT_{od} = The amount of pocket cost of the trip by auto between the origin and destination

It should be noted that DUB and ABA are modified for captive users in a similar way for the access and egress portions of the trip. That is, the disutility of the access and egress portions of the trip are increased to take trips by captive bus riders into account.

Disutilities are calculated for an all auto trip and an ABA trips and compared to the disutility of the original bus trip to determine the disutility savings of the intercity bus service. To the extent that disutility savings can be regarded as a measure of benefits, this process allows an analysis of the effects of various factors on the benefits of intercity bus service. The savings in disutility (DUS) for an intercity bus trip is then:

$$DUS = \text{Min} \begin{cases} DUA - DUB \\ ABA - DUB \end{cases}$$

The disutility savings from the previous equations has to be greater than zero for there to be any direct benefit of the intercity travel.

To extend this calculation to the route level, the disutility savings must be calculated for all stations along a bus route, multiplied by a population weight and divided by the value of time to create the benefit index for a particular intercity route:

$$BI = (DUS_k)\ (PW_k)\ (C_2)$$

where

- BI = Benefit index
- DUS_k = Disutility savings of intercity bus at town k in minutes
- C_2 = Value of time in cents per minute
- PW_k = Population weight for station k. This is an indicator of the activity of station k; ideally it is the number of boardings, but could also be given as follows:

$$PW_k = T\ (P_k / \sum_{k=1}^{n} P_k)$$

with

- T = Annual trips on the route
- P_k = Population of town k
- n = Number of towns along the route.

This equation yields a number which represents the dollar equivalent of the disutility savings for all users along an intercity bus route. It is referred to as a benefit index rather than simply as the benefits of a service because it does not include non-user or freight benefits.

Non-user benefits, and the value of freight service should be separately recognized when benefits of a service are being analyzed. Furthermore the processs also has an inherent assumption that all travelers are willing to pay for the trip by an alternative choice rather than to forgo the trip. The shape for the demand curve would have to be known to adjust for this factor.

An Application to Two Rural Intercity Bus Routes in Wisconsin

Two intercity transit routes in Wisconsin were examined to apply the model and to demonstrate its use as a means to calculate the relative benefits of different intercity bus routes. The cases used were bus service between Green Bay and Milwaukee via Plymouth, Wisconsin (Green Bay - Milwaukee) and service between Ashland and Abbotsford, Wisconsin. Each route is served by one bus a day in each direction. The Milwaukee - Green Bay route has alternative service available relatively close by and is located in a populous area of the state. The Ashland Abbotsford service is isolated from other services and located in a sparsely populated part of the state.

A spreadsheet program was used to calculate the benefits index for these two routes. A base case was developed using the following values for the parameters required by the model. Auto travel is assumed to cost 25 cents per mile with average speeds of 25 mph for local travel and 50 mph between cities. An auto cost of $0.25 per mile was used to represent average costs rather than marginal costs in order to calculate benefits on a comparable cost to bus where fares are related to average costs. Bus costs are 14.04 cents per mile (actual bus fare) and an average speed of 45 mph. Bus and automobile out-of-vehicle times are initially set at 15 and 5 minutes. For an all auto trip, the total out of vehicle time is 5 minutes. For an ABA trip, there is a total of 25 minutes out of vehicle time (5 minutes for auto access, 15 minutes for bus waiting and 5 minutes at the destination city spent waiting for a connecting ride). The coefficients for the disutility equation are 3.0 minutes per minute for out-of-vehicle time multiplier (C_1), 8.33 cents/minute ($5.00/hr.) for the value of time (C^2) and bias coefficients of 20 minutes for bus and 0 minutes for auto (C^3). A direct intercity bus or auto trip requires a one-mile local access trip and a 5-mile egress trip. The ABA trip requires different access distances depending on the particular station and the location of the alternative bus route. Initially, it was assumed that 50 percent of the users had no automobile available for the trip and that the annual ridership was 1,000 users in each direction. It should be noted that these are assumed ridership figures, and they represent very low passenger volumes of approximately three passengers per trip.

Using these values, the benefits for the Green Bay - Milwaukee route are $3,727 or $1.86 per trip and $7,453 or $3.73 per trip for the Ashland to Abbotsford route. The difference between the two routes relates primarily to the fact that the Ashland - Abbotsford route is more isolated from other service (an average of 35.6 miles) than the Green Bay - Milwaukee route (an average of 15.4 miles). This leads to a larger gap between disutilities of the modes and hence a larger benefit index. This indicates the effect of the distance to the nearest bus on the disutility calculation for a given station. If the alternative station is remote, the size of the benefits index is large because it depends upon auto travel rather than bus service. An additional factor which leads to a higher index for Ashland - Abbotsford is that the route is somewhat longer (133 vs. 144 miles). Since disutilities are a function of distance, this adds to the index for that route.

These results imply that the importance of a service depends not only on the magnitude of the ridership but upon the relative isolation on the route. Those routes which are the only service for a large but lightly populated area would tend to have a larger benefit index on a per passenger basis than routes in an area of more dense coverage. Accordingly, policies that relate to public support of intercity bus service should be route specific and consider the effects of alternative services. This analysis does not include a cost estimation technique, but costs can be estimated using techniques presented in Chapter 3, and compared to the benefits estimated using the disutility index.

SUMMARY

This chapter has presented two methods for performing cost-benefit analyses; one dealing with capital projects, and the other with operating assistance. Though the examples provided cover the rail freight and intercity bus modes, it should be noted that cost-benefit analysis can be used for virtually any type of project. The analysis does become a good deal more complex when external costs and benefits are included in the analysis, particularly if they are not normally valued in dollar amounts. Environmental factors, indirect employment impacts, and other factors can add a great deal of detail and complexity to the analysis; they have not been treated here at all. The cost-benefit analysis says nothing about distributional questions. No comment is made regarding the distribution of the benefits gained among all members of the population, only the assumption that through costless transfer payments, everyone could be made better off. The lack of distributional considerations may be a flaw in the case of the analysis of bus service abandonment, since bus users as a group tend to be economically much less well off than travelers in general. Similarly, the cost-benefit analysis of rail service presented in this chapter has not dealt with the job impacts of rail abandonments and the possible distributional effects of job losses for particular groups or regions. These impacts should also be considered in the analysis of public actions to improve or maintain rural intercity services. Should the type of project analysis presented in this chapter result in recommendations that are not clearly for or against the project, external factors may need to be included.

6

CHOOSING THE BEST INTERCITY SERVICES

In planning for intercity transportation services serving rural areas and small communities, officials may initially be concerned that choices between modes are being made without complete information as to which is the "best" mode. Proponents of particular modal services usually are able to muster statistics showing that their particular type of service is the safest, most energy efficient, lowest cost, most environmentally sound, or otherwise beneficial. Still, there are differences between the modes that should be taken into account in the planning process.

Each of these modes has a niche in the transportation marketplace based on its cost, its productivity, and the size, type, and density of the particular market. If relationships between the technological characteristics of the mode and the demand are ignored in the course of planning, the service is likely to be unsuccessful no matter what the proponents of the mode would like to have happen.

For these reasons, this chapter compares modes to provide an indication of the type of situation in which a particular mode is likely to be most successful. Public decision-makers -- including elected officials and planners -- should be aware of these differences early in the planning process, in order to avoid developing alternatives that have no real chance of implementation. One should be able to recognize a case in which a choice of modes is possible, or where introducing a new mode may have effects on existing services. This chapter is intended to assist in the early planning stages by providing a framework for comparing the modes.

PRODUCTIVITY MEASURES FOR ALTERNATIVE MODES

There are two factors to be balanced in the selection of the appropriate mode: one is the market for the services that will be produced (and its characteristics), and the other is the niche within which a particular mode is most productive. To illustrate this latter point, productivity measures often applied to air service analysis have been calculated for intercity bus and rail passenger service.

The measure chosen for this comparison is available seat-miles per hour. Available seat-miles (ASM) was discussed in the analysis of short-haul airline costs in Chapter 3. It represents the seating capacity of a particular vehicle times the miles produced. Dividing it by hours includes speed in the measure of productivity. Table 6-1 presents some typical modal productivity measures for intercity bus, regional airlines, and Amtrak 403(b) rail passenger service. Using a measure such as this, larger and faster vehicles will always appear to be more productive.

Cost is another factor which must be considered in productivity. Rather than provide dollar figures as cost information, the ASM/hour measure for each of the modes can be divided by the typical crew size to give an overall indication of output per crew member for each mode, assuming that operating costs are directly related to crew size. As can be seen in Table 6-1, the required crew sizes per vehicle vary by mode, and have a substantial impact.

In general, the rail passenger service with a minimum crew of four begins to have the same productivity as the intercity bus when train length is at least three cars, improving with additional cars up to the point where additional crew members are required. If the analysis of demand indicates that rail ridership will require that many seats per train, given an allowance for a load factor of 60 percent, then both intercity bus and rail service should be included in the analysis.

Comparing regional airliners and intercity bus, one notes that for the 19-seat airliner, the productivity per crew member increases with distance of the route, because the time spent in landing and takeoff decreases as a proportion of total trip time, and the inherent speed advantage of the plane becomes more apparent.

Another element of cost is capital cost. Obviously, the prices of aircraft, buses, and locomotives and coaches vary considerably. Table 6-1 also presents

Table 6-1: COMPARISON OF TYPICAL MODAL PRODUCTIVITIES: PASSENGER SERVICES

Vehicle	Seating Capacity	Operating Speed (MPH)	Available Seat-Miles/ Hour	Crew Size	ASM/HR/ Crew Member	Capital Cost (1987)	Capital Cost/Seat (1987)
Intercity Bus Coach	47	45	2,115	1	2,115	$ 180,000	$ 3,830
Commuter Airline -- Fairchild Metro III						$2,950,000	$155,263
a. 75 mile stage length	19	167	3,167	2	1,584		
b. 150 mile stage length	19	204	3,886	2	1,943		
c. 275 mile stage length	19	235	4,479	2	2,240		
Commuter Airline -- Dehavilland Dash 8						$6,000,000	$166,667
a. 75 mile stage length	36	167	6,000	3	2,000		
b. 150 mile stage length	36	220	7,902	3	2,634		
c. 275 mile stage length	36	239	8,609	3	2,870		
AMTRAK 403(b) Service							
a. 2 coaches + 1 cafe/coach	150	45	6,750	4	1,688	$3,750,000	$ 25,000
b. 3 coaches + cafe/coach car	210	45	9,450	4	2,363	$4,500,000	$ 21,429
c. 5 coaches + cafe/coach car	330	45	15,850	5	2,916	$6,000,000	$ 18,182

Source: Compiled by Ecosometrics, Incorporated. Aircraft data from The 1986 Annual Report of the Regional Airline Association, pp. 37-43. Amtrak seating estimated at 60 seats per coach, plus 30 seats per coach/cafe. Locomotive costs are approximately $1.5 million apiece, + $75,000 per coach.

some typical purchase prices for new equipment, along with the capital cost per seat. Obviously, the bus is the cheapest, the train somewhat more expensive, and the aircraft much more expensive. However, on an annualized basis over the likely life of the vehicle, the differences will change somewhat as the higher capital costs of the train and plane result in higher interest costs, and their longer expected service life lowers their costs when compared to the bus.

These comparisons indicate that each of the modes has particular advantages in productivity that should be taken into account in the analysis. In general, if the productivity of the bus is used as a baseline for comparison, the regional airline is preferred over longer distance routes, or when frequency of service is important. Rail passenger service requires a higher density of ridership than bus service as the capacity advantage is only exploited when the projected demand exceeds that which could be met by three or four intercity coaches over the same route. Obviously, the critical task is matching the mode to the characteristics and size of the demand.

DEMAND FACTORS TO BE INCLUDED IN MODAL COMPARISONS

For any matching of modes to markets to be successful, both the size and the characteristics of the demand must be considered. Because of differences in income, trip purpose, and modal preference on the part of users, decision-makers must recognize that different modes serve particular segments of the intercity travel market. The number of situations in which a choice must be made between supporting one mode versus another will be limited.

Table 6-2 presents user characteristics by mode, developed from national statistics from the 1977 Census of Transportation. In general, bus passengers tend to be young adults or senior citizens, to have lower income levels, and to have less education than air or rail passengers. Table 6-3 shows trip purpose by mode, and the major conclusion must be that most bus and rail travel (except for the Northeast Corridor) is for non-business purposes, while almost all business travel goes by air. Of course, the private auto is the overwhelming choice of most travelers of all kinds. These two tables clearly indicate that the intercity travel market is separated into business and non-business components. Business travel moves by air or by auto (private or rented) -- with a few exceptions -- because of the high value on travel time

Table 6-2

USER CHARACTERISTICS, BY MODE
TOTAL TRAVELERS

	Auto (a)	Auto (b)	Bus	Rail	Air
Median Income ($)	16,081	17,136	12,996	17,927	18,975
% Black or Other	7.88	2.41	20.52	15.96	7.84
% Spanish Origin	3.74	3.81	4.79	1.38	3.90
Mean Age	32.00	29.50	33.20	36.50	37.50
Median Age	28.60	26.80	23.80	33.20	35.30
Education					
% Elementary	30.12	34.06	34.82	20.20	16.13
% High School	42.44	42.71	42.74	30.45	36.26
% College	27.44	23.22	22.44	49.35	47.67
Sex					
% Male	49.81	54.60	38.75	49.75	50.20
% Female	50.19	45.40	61.25	50.25	49.80
% Non-SMSA Residence	32.36	33.59	30.25	19.15	18.34

Notes: (a) Auto/Truck Trips (Without Camping Equipment).

(b) Auto/Truck Trips (With Camping Equipment).

Source: Compiled from: U.S. Department of Commerce, Bureau of the Census, 1977 Census of Transportation, National Travel Survey, Travel During 1977, Report TC77-N-2, Washington, D.C.: U.S. Government Printing Office, pp. 35-39.

Table 6-3

USER CHARACTERISTICS, BY MODE
TOTAL TRAVELERS

Trip Purpose (% Household Trips)	Auto (b)	Auto (c)	Bus	Rail	Air
Visit Relatives or Friends	35.69	18.72	23.62	36.02	22.02
Business	21.90	5.76	4.56	37.16	50.69
Convention	1.83	1.13	3.89	2.32	4.11
Outdoor Recreation	11.69	45.80	10.69	2.27	2.67
Entertainment	7.09	8.77	16.79	5.77	5.47
Sightseeing	3.77	9.08	13.85	4.49	4.73
Personal, Family, or Medical Affairs	12.99	5.70	7.83	10.48	7.09
Shopping	0.82	0.24	0.80	0.36	0.06
Other	4.22	4.80	17.95	1.11	3.17
Round Trip Distance (In Miles)					
Mean	487	710	585	878	1845
Median	338	400	396	456	1586
% Destination not in SMSA	45.70	61.65	29.62	10.12	13.11
Mean Number on Trip	1.8	2.2	1.2	1.3	1.2

Notes: (a) Auto/Truck Trips (Without Camping Equipment).

(b) Auto/Truck Trips (With Camping Equipment).

Source: Compiled from: U.S. Department of Commerce, Bureau of the Census, 1977 Census of Transportation, National Travel Survey, Travel During 1977, Report TC77-N-2, pp. 13-22.

for such trips. Non-business travel takes place by air (on restricted discount fares), by train (for middle-income persons), and by bus. Travel party size is also a key factor, as the cost of auto travel per person decreases substantially with additional passengers. Bus and rail ridership will therefore tend to be individuals travelling alone for primarily social or recreational trips. Travel time is less important, as is frequency.

Overlapping markets for the modes are therefore limited. The short-haul air passenger market competes with the bus market only in cases where the modes have common destinations, such as a major hub airport, and the overall travel time from a small city is approximately the same, perhaps up to 125 miles in length.[1] Even then, factors such as quality of service, frequency, parking costs and congestion may tip the balance in favor of one mode. Cross-subsidies from major airlines to their regional affiliates on long distance interline fares may well reduce the total cost of a trip by air to levels below the combined airport bus/line-haul air fare.

In terms of bus versus rail passenger service, much has been written concerning the impact of competition. The trip purposes and passenger characteristics of both modes are similar, the major difference being the income and education levels. Certainly it appears that if both modes are available at similar fares in the same market, users will favor the train. However, the total size of the market must be sufficient to justify rail service, or the cost of that option will rule it out. Train service should only be considered for the non-business market in cases where the daily demand requires at least three to four cars. Otherwise, the appropriate mode for non-business travel is probably the intercity bus, if demand is sufficient.

FREIGHT COMPARISONS

Shippers and receivers of freight must include many variables in their calculations regarding the appropriate mode. In addition to the freight rates themselves, loss and damage costs, the interest cost on the value of the goods during that period of time that they are in transit, and costs related to reliability must enter into the equation. Rate structures usually embody

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[1]Simat, Helliesen and Eichner, Inc. Alternative Ground Service for Small Communities. Prepared for U.S. Department of Transportation, Office of the Secretary, p. I-4, I-B.

components related to the distance of the haul, the weight, size and density of the product being shipped, the amount of handling it will require, and its fragility. Because of this, shipper decisions will hinge on rates and the other costs involved in transportation, rather than on any other kind of modal preference.

The use of cost comparisons, as described in the cost-benefit analysis for rail projects, is probably the most appropriate means of making this comparison. However, decision-makers will quickly realize that the rail market to or from rural areas is largely confined to low-value bulk commodities, such as coal, building materials, fertilizer, grain, and chemicals. High value, manufactured products are likely to be strictly truck markets, unless extremely bulky. Trailer or container on flat car service is the means by which such higher-value products use the rail system. Since the pickup and delivery of such items to intermodal terminals is by truck, rural branches will rarely be involved in such shipments. Rather, the importance of the rural services is in the fact that agricultural and other natural resource-based inputs and products fall into the low-value, bulk commodity classes which are best moved by rail. Such areas may find that assistance in maintaining low-cost rail service may be justifiable.

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